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ABSTRACT

This instructor's guide contains materials for a course designed to prepare employees for statistical process control (SPC) training given at their workplace by refreshing math skills and building the concepts and vocabulary necessary to understand SPC in manufacturing environments. SPC-Prep 1 addresses the math skills necessary to perform SPC calculations. SPC-Prep 2 includes application of the math concepts in SPC situations and the building a base of vocabulary and major concepts for actual SPC training. The course description lists target audience, general objective, and typical results observed. The next section gives instructors basic information related to providing successful educational programs in a workplace setting, an instructor's lexicon of strategies and principles that can be used in teaching, instructor's role and responsibilities, and course objectives. An explanation of lesson format lists six parts of the lessons--outcome, materials, demonstration, exercise, workplace application, and evaluation. A sample template and explanation of each part follows. A section on planning and scheduling deals with time requirements, class size, expected outcomes, prerequisites, and suggested timing for each lesson. Topics of SPC-Prep 1 lessons are as follows: math memories; keeping track of learning; math operations; place value; rounding off numbers; finding an average; decimals; and positive and negative numbers. Supplementary lessons focus on fractions and finding percentages. A word list, glossary, and preview and review with scoring guide are provided. Topics of SPC-Prep 2 lessons are as follows: keeping track of learning; quality in the workforce; statistics; SPC terminology; tables, charts, graphs; acceptable range; and QS (Quality Standards) 9000. A preview and review with answer key are appended. (YLB)

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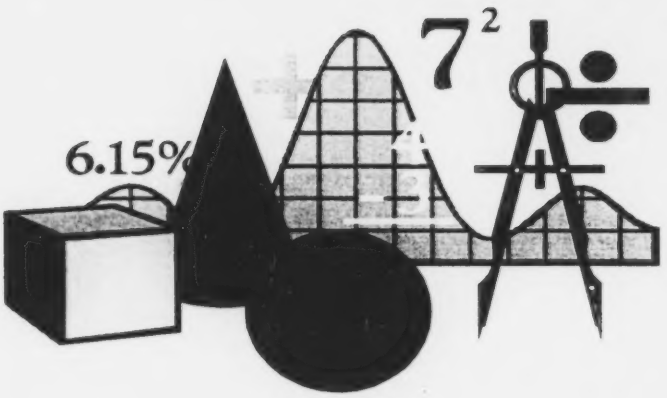

SPC-Prep

Instructor's Guide

Part 1 – Math Refresher
Part 2 – Concepts and Applications
of Statistical Process Control

Nancy Ruetz

Project ALERT

CE 077 300

Wayne State University
College of Education

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Overview of SPC-Prep 1 and 2

Description: This course is designed to prepare employees for SPC training given at their workplace by refreshing math skills and building the concepts and vocabulary necessary to understand Statistical Process Control in manufacturing environments. SPC-Prep I addresses the math skills necessary to perform SPC calculations. SPC-Prep II includes application of the math concepts in SPC situations as well as the building a base of vocabulary and major concepts for actual SPC training.

Major topics in SPC I include:

- Mastery of addition, subtraction, multiplication, and division of whole numbers, and decimals. (Supplementary fraction lessons included)
- Mastery of place value in regard to decimals.
- Mastery of addition and subtraction of signed numbers.
- Mastery of calculating averages

Major topics in SPC II include:

- The changes in the need for quality through history to the present.
- SPC--What is it? What is involved? How is it accomplished?
- Benefits of using SPC for maintaining quality
- The relationship of SPC to QS9000
- Application of vocabulary, concepts, and math skills.

Length of Time: SPC-Prep 1 is dependent on the math backgrounds of students, typically 24 hours of instruction.. SPC-Prep 2 can be interwoven in the SPC-Prep 1 or taught separately. It is about 12 hours of instruction.

Target Audience: All employees who are expected to take SPC training.

General Objective: Participants in SPC Prep 1 will improve math skills necessary to SPC. Participants of SPC Prep 2 will build a foundation of vocabulary and concepts that will help them successfully complete SPC training.

Typical results expected: Participants will know and use accurate terminology for SPC. They will have the necessary math skills to make SPC-related calculations. Participants will be aware of the need to upgrade skills for today's manufacturing environment.

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Rationale for Curriculum Approach

The Whole Language philosophy provides the best approach for developing the learner. It supports success in the classroom and on the job. The integration of the curriculum reinforces all of the skills required to improve job opportunities. The key to providing a successful Whole Language program is assuring that every learner will be recognized as a potentially successful student. The learners must be co-partners in this collaborative effort. Learners are an integral part of the learning situation. They are valued for what they bring to the learning experience. The instructor is regarded as a facilitator of learning rather than the major source of knowledge and information.

Recognizing and building upon their unique past experience is crucial for integrating new learning. In this process, continual dialogue and interaction are key to the instructional process. The curriculum is built on the learners' strengths, not weaknesses, and accommodates the variety of learning styles and cultural orientations. It also encourages the learner to assume responsibility for his/her own learning. Recognition of success in the classroom enables learners to feel good about themselves. Learners become empowered workers by understanding the job process and how they contribute to the big picture.

Overall, raising the learners' level of self-awareness on the job, in the home, and in the community, will create a more satisfied and productive member of the work force.

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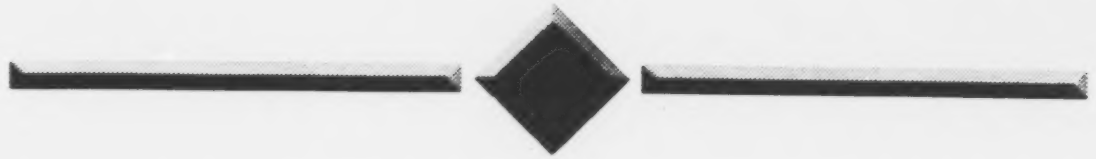
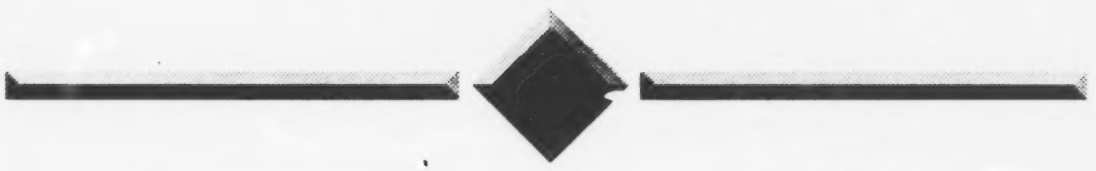


Making it Work



This section of materials is provided to give instructors basic information related to providing successful educational programs in a workplace setting.

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Adult Learners

General characteristics of adult learners:

1. Purposeful learning occurs with adults experience a problem or recognize a gap between where they are and where they want to be, then start to draw on resources to acquire the learning they consider necessary to close the gap.
2. One of the most important issues to consider from the adult learner point of view is "What's in it for me?" An adult needs to know that there is real value in what is being taught. Customize and adapt lessons to suit your students. Make a regular effort to point out what benefit the instruction has for the student. Many times students are unaware of the applications of learning. Make sure you point out possible applications of knowledge.
3. Adult learners insist that learning have relevance and value now, contrasted to youthful learners whose education is largely subject-centered and future-oriented. Most adults are already busy with their jobs and families, so the learning must be worthwhile.
4. Adult learners will drop out of educational situations that are seen as not accomplishing their own agenda.
5. The central organizing principle for adult learning must be around finding solutions for problems adults face. Emphasis must be on helping adults learn to cope with problems they face. Therefore, the instructor must be more *person*-centered than subject-centered.
6. Adult learners are well aware of what they need to know, and they like to participate actively in all phases of their education--assessment, instruction, and evaluation.
7. Many adult learners come into programs with the "baggage" based on a history of negative educational experiences. It is absolutely essential to provide a safe, non-threatening atmosphere where risks can be taken with out fear of humiliation or embarrassment.

Environment

Creating a safe environment for learning is a key factor in success. One of the elements that is part of a safe environment is multicultural sensitivity. The following suggestions should be considered as the lessons are delivered:

1. Use multiple instructional strategies to accommodate all learning styles. See *Learning Styles* for more information on this topic. Also see *Teaching Auditory Learners, Teaching Kinesthetic Learners; Teaching Visual Learners.*
2. Avoid ethnocentrism (belief in the superiority of one's own ethnic group), use of stereotypes, critical or judgmental attitudes, fear, and rigid expectations. Strive to

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address the various cultures represented in the group. Try the AAAA approach to Cultural Diversity: Awareness; Acceptance/Appreciation; Action

3. Seek to understand the unique motivations of your audience in the workplace. Each worksite has a particular culture. It is important that you strive to understand and become a part of that unique culture.

4. Use materials that are not slanted toward any particular group.

Above all, the instructor must establish a learning environment in which diversity is valued. Students need to feel that their cultural backgrounds are viewed as assets to the class.

Teaching Auditory Learners

(Adapted from materials from presentation, *Designing Workplace Training to Accommodate Culturally Diverse Learners*, Douglas Jones, Linda Mrowicki, Workplace Education Division of THE CENTER-RESOURCES FOR EDUCATION, delivered Jan. 1996.)

Auditory learners learn best by listening to others. They usually do well in a "traditional" classroom.

Audio tapes: Have students or groups listen to a tape or create their own tapes for each other to listen to.

Music: Record key points on an audio cassette with background music. Write a song, rap, jingle or rhyme about the learning material.

Guest speakers: Invite subject matter experts to talk about a topic. This can be outsiders or members of the class.

Reading: Read or tell a story, for variety use music in the background.

Discussions: Use questions to get others in the class involved. Not only can students learn from the instructor, but they can learn by listening to each other, and the instructor can learn from listening to the students.

Repetitions: Repeat things out loud.

Directions: When giving directions, be sure to give them orally.

Mnemonic devices: Mnemonics are artificial aids to memory. The keyword HOMES can be used to remember the names of the Great Lakes; H = Huron O = Ontario M = Michigan E = Erie S = Superior. Sentences and rhymes can also be used; to remember which direction to turn a screw to tighten = Leftie Loosie, Rightie Tightie. Steps in basic division can be incorporated into the sentence: Donald (or Donna) made some candy bars = D = divide M = multiply S = subtract C = compare B = bring down.

Be the Instructor: Pair the class and have one individual teach the other, then reverse roles.

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Concert Review: The instructor uses transparencies, pictures, charts, etc. that were used in presenting the lesson as a means of review. While playing soft music, the instructor displays and reads the instructional materials. A variation is to have a willing student read the instructional materials.

Oral Cloze: Use oral cloze (fill in the blank) activities to repeat key information

Teaching Kinesthetic Learners

(Adapted from materials from presentation, *Designing Workplace Training to Accommodate Culturally Diverse Learners*, Douglas Jones, Linda Mrowicki, Workplace Education Division of THE CENTER-RESOURCES FOR EDUCATION, delivered Jan. 1996.)

Kinesthetic learners learn best by doing. They like to be physically expressive. They also need to stretch and move periodically. The following are activities that enhance kinesthetic learning.

Walking and studying: Allow students to walk while they study.

Role playing: Use props and costumes while role playing. Can be done with a group or in pairs.

Action learning: Includes anything that requires people to use their bodies in some way while they learn. It could be a song, a dance, a mime, a physical acting out of a technology or process, or an active performance of the learning material where learners become interacting components of the material they are learning.

Strolling review: Have the group prepare colorful flip charts as a means of review. Hang them around the room Play music softly as individuals walk silently around the room, carefully observing the wall display or examining the mind maps created by other learners. A variation is to play music while individuals stroll around and review.

Being the Coach: Ask one partner to be the coach while the other partner learns to perform a new task. After one run, reverse roles.

Demonstrating: Allow class members to demonstrate and physically do an activity. Provide opportunities for practice using repeated motion.

Writing: Writing requires students to use parts of their bodies. Write on surfaces with a finger. Write in the air. Trace on sandpaper. Take notes. Write lists.

Sequencing: Using a topic that has several steps or procedures, give each individual a piece of paper with the words or a graphic depicting one step or procedure. Ask the group to move around until they are in the correct sequence. An option is to act out what is on their piece of paper.

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Teaching Visual Learners

(Adapted from materials from presentation, *Designing Workplace Training to Accommodate Culturally Diverse Learners*, Douglas Jones, Linda Mrowicki, Workplace Education Division of THE CENTER-RESOURCES FOR EDUCATION, delivered Jan. 1996.)

Visual learners like to process, store, and retrieve information visually. The following are examples of activities that instructors can use to facilitate the visual learner.

Demonstrations and modeling: Since visual learners like to understand the "big picture," it is important to show or model all of what is expected before breaking it into its components.

Draw: Simple illustrations can be used to reinforce important information. Encourage students to draw as a means of committing key information to memory.

Imagery: Imagery is the mental visualization of objects, events, and arrays. The typical technique is to ask students to form a mental picture. It usually works best for concrete information and less well for abstract information. Images are better remembered if they are vivid and show some type of movement.

Study Guides: Study guides are used to summarize key information. They are useful for reviewing key points. Instructors can create study guides, or better yet, allow students or groups of students to prepare a study guide.

Graphic organizers: These are visual tools which can show the relationship of categories of information. Charts, graphs, and maps can be used to show relationships visually. They are also good because they usually show or explain a concept holistically. Instructors can create blank charts or matrices for the learner to complete.

Mental Imagery: Have learners rehearse or practice a knowledge base or a skill in their minds.

Mind mapping: Ask individuals to mind map a lecture or presentation, a written lesson, an article, an audio tape, a recollection, an experience, or anything relative to the learning situation that might be significant.

Note taking: Encourage visual learners to take notes using words or pictures. This provides them with another opportunity to visually rehearse the information. Note taking can also be done using a map which allows them to see the "big picture."

Create notebooks: Using notebooks for class projects provides another way for students to see the information in their own words. It allows them to "customize" the information and make it their own.

Color codes: Visual learners like to see different things/views. Use color as a means of focusing attention, or use it as a means of changing the environment to add interest visually.

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Study cards: Study cards use the visual sense to present the information. They can be used individually, with partners, or in large groups. Cards can be prepared by the instructor or students can prepare their own.

Pictures: Watch TV, filmstrips, movies, videos, etc. Another option is to have the group create their own video.

Mnemonics: Create acronyms, draw visual chains, or develop acrostics.

Directions: When giving directions, give them visually.

Tips on Teaching

1. Use logical sequences. Avoid jumping into topics without developing background or relevance for the skill at hand.
2. Control length of lessons into manageable chunks. Many employees come into classes at the end of a long and tiring day. Pace lessons so students can have short breaks.
3. Give recognition and encouragement. It is vital that you recognize and encourage all your students' progress toward their individual goals. Unfortunately, often adult learners are not supported by friends and family who view time spent in class as time taken away from them.
4. Use coaching. Model new skills. Point out the problems or pitfalls many students have with lessons. Repeat explanations several times or a period of time and several ways to accommodate all learning styles. Be there for them.
5. Encourage involvement. Make sure students hear you validate how important it is to learn new skills. Techniques that make provisions for active involvement of students will achieve learning faster than more passive teaching techniques.
6. Give feedback. Adults need to be reassured that they are on track. Give feedback often, and be sure to give negative feedback along with something positive.
7. Use summaries and advance organizers. When materials are detailed or involved, help students see the "big picture."
8. Questions will help you assess how your students are understanding. Make sure they are not accusatory in tone. It is possible to inadvertently press a "hot button" based on a students' unpleasant school memories. Maintain a safe atmosphere for students when questioning them.
    - Direct questions are usually *yes* or *no*, or short answer. They are easy to control.
    - Open-ended questions are more likely to prompt discussion. They are not as easy to control.

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Instructor's Lexicon

The following lexicon is provided to remind teachers that there are a variety of strategies and principles that can be employed in teaching. When you are not getting the response you expect, when faces are blank or bored, when attendance starts to slip--*try something else*.

Anticipation Guides (Readance, Bean, and Baldwin) Prepare students for reading by asking students to reach to a series of statements prepared by the teacher in advance. Expected response is TRUE or FALSE.

Application of concepts to different situations- learning that is applied immediately is retained longer and is more likely to be used immediately than that which is not. Techniques must be employed that encourage the immediate application of any material in a practical way.

Application to individual situation --Provide real life or real work scenarios for which students read different texts to solve problems

Article/pictures

5 W's (Who, What, When, Where, Why/How)
Antonyms/Synonyms
Match or rewrite topics/headlines
Change time, place, people and rewrite
Write questions with higher levels of critical thinking

Brainstorming--All responses are accepted, no judgment. Activates background knowledge. Gets students thinking before they read or write.

Cartoons- students fill in blank balloon with appropriate response

Categorical Overview-- Write down associations , think how they are related, categorize information, and label.

Cloze-- It is a method of systematically deleting words from a prose selection and then evaluating the success a reader has in accurately supplying the words deleted. In a given passage the first and last sentence is provided in tact. Thereafter selected deletions are made. *Ex.* Every 5th or 10th word; Initial/final letter; Word/ phrase; All nouns or verbs, etc.

Clustering-- Similar to mapping, adds visual dimension to the process of organizing ideas, helps students separate ideas into categories. Improves organization of thoughts for speaking or writing.

Coded Vocabulary--Student marks words that he knows with an asterisk, check mark for words he has heard of, and circles the words that he does not know.

Compare and contrast--Write or discuss similarities (compare) and differences (contrast)

Concrete Items/Demonstrations-- Including actual items in classes helps those learners who need more tactile or kinesthetic learning experiences understand. Visual and audio learners have an easier time with traditional formats than other kinds of learners.

Continuum of Descriptors--Write adjectives on a line to show degrees of modification, such as minuscule, tiny, small, average, big, huge, enormous

Cued Retelling (See article on Retelling--Free and Cued)

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Cubing--On a paper cube, write down one of the following words on each side of the cube: describe, compare, associate, analyze, apply, argue for. When writing or discussing an object/concept, have students write about it using the suggestions from each side of the cube.

Designated Roles (Cooperative learning)

Listeners note points of disagreement
" " what is not said
" " questions to ask

DRAT (Directed Reading/Thinking Activity-Haggard, 1985)

Activate prior knowledge
Predict what will be covered
Read to designated point
Confirm, revise, or elaborate prediction with information from text
Continue in similar fashion through text.

Dyads confirm/explain
make decisions
draw conclusions

Find someone who . . . --an ice breaker activity to raise awareness of the depth of experience and diversity in the class. Typically you can only get another person to sign your sheet once. Categories can be as generic as "find someone who has more than 5 brothers and sisters" or "find someone who speaks another language" to class specific information like "find someone who has read a the work of Edgar Allan Poe." It can be designed for many topics but always helps students get comfortable with each other.

Flash card directions--Challenge learners to read more than one word at a time by giving direction quickly on flash cards. Ex. Put your hands on the table.

Free-writing/thinking

Can you think of a time . . .
Questions regarding topic

GIST--requires readers to reduce the first sentence of a passage to 3 or 4 words. The next two sentences to 5 or 6 words. The next three sentence to 7 or 8 words. This requires readers to make meaning and determine their own key words.

INSERT (Interactive Notation System for Effective Reading)--Students place a √, X, +, !, ?, ?? and * besides ideas they read to indicate whether they understand it (√), are excited about it (X), don't understand it (?) , are stumped by it (??), or want to remember it (*).

Interviewing--Encourage students to generate a list of questions that would give them the information they would like to find out about someone. Have students break into pairs and interview their partner, using questions. Then let each introduce his/her partner using the information obtained.

Jigsaw/segmented reading --Instructor assigns parts of a selection to different readers. Readers read their part silently. Each reader shares what they read with group.

Journals--Students write reaction to class, write comments, write questions. Instructor does not judge them on technical competencies. May be used to tie topic of class to learner. If topic is American Education, journal writing questions could be: Where did you go to school? What did you like best in school? What irritated you the most? Why did it irritate you? Who was your favorite teacher? Why did you come to this class?

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Key word predicting activity--Instructor selects passage and notes 10 key words. Words are shared with learners who are asked to predict content. Learners should try to make sense of key words. Next, learners read passage and find out if predictions are on target.

K-W-L--(Ogle, 1986) Students identify what they **K**now about a topic , what they **W**ant to find out about a topic, and what they **L**earned about the topic.

LEA (Language Experience Approach, Stauffer, 1970) Students dictate sentences about an experience as instructor transcribes. This text become the reading material for that student.

Learning style--The 3 major learning modalities:

Visual-needs to see material
Auditory-needs to hear material
Kinesthetic- needs to move around while learning

LINK-- L= List I= Inquire N=Note K=Know List all associations for concept/topic on overhead/chart; inquire - give examples, clarifications about associations; note - write what comes to mind for one minute (overhead off/chart covered); know - what I know now about this concept/topic?

List and skip-- instead of looking up words as you read, use a *List and Skip* bookmark. Write down unfamiliar words from reading selection. After completing selection, look to see if any words were understood through use of context.

Main Idea-- explanation overheard by instructor between students. "How would you tell your mama what the (article, book, chapter) was about if you were calling her long distance?

Mapping (Baumann, 1991)--Arranging key terms into a diagram that is meaningful to the student. It can include the following:

Key words/phrases
Structure
Questions
Connecting lines/circles

Is a graphic representation of the relationship between major ideas and supporting details.

Metacognition - Being aware of how you learn, and the process of thinking through a learning situation. The development of self-questioning or monitoring of patterns of thinking, which helps students become an independent learners who can recognize and correct their processing errors.

Questions with others

What do you think about . . .?
Why is . . . used for . . .?
What would you do if . . .?

Paired Questioning --Divide students into pairs, read passage, close book. Each in turn asks questions with the other answering; tells important ideas; paraphrases or summarizes; agrees/disagrees; draw picture or graphic representation of what learned.

Reading strategies-- Good readers bring what they know about the topic to the print on the page. They are active readers. Good readers take chances, they risk being wrong. Good readers guess at or skip words they don't know and read on for help. Good readers

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expect the material to make sense. Good readers try to match reading speed to what they are reading.

Reading techniques

see: Flash card directions
see: GIST
see: Key word predicting activity
see: List and Skip
see: Word Bank

Reciprocal questioning

Students work in pairs
Both read a portion of a reading selection.
One asks the other a question.
Continue reading selection
Alternate asking questions.

Retelling/rewriting- Can be free retellings, cued retellings, and/or cued comprehension questions. Provides an opportunity for students to reflect and revise their thoughts. Teachers can record students thoughts without having to infer right or wrong choices. Possible prompts: *Write down everything you can remember about the selection you just read.* Provide a list of words from the passage, and then, *Use these words to help you remember everything you can about the passage. See Retelling--Free and Cued*

Retelling--Free and Cued - A free retelling allows a reader to structure his or her demonstration of comprehension without the constraints often imposed by a testing situation. If the objective of the assessment is to find out how the student is thinking about the content rather than how much he can demonstrate that he knows, the unprobed (free) retelling is probably the best response.

Researchers find the free written retelling to be an invaluable tool as they explore issues related to reading comprehension. Retellings allow analysis of the link between the response and the original source (the text). Many teachers are reluctant to use them because they do not lend themselves easily to objective scoring.

Since remembering and understanding are not synonymous, there is value to using retrieval cues as an aid to comprehension. By including word or phrase cues the reader has the freedom to indicate his or her comprehension according to personal dictates while simultaneously providing bits of text to help dissolve the confusion between what is understood and what is remembered. **Cued retellings** may be the best of both worlds.

In order to do this form of assessment, the teacher needs to have comprehension questions in mind. the perspectives on comprehension that are to be checked should be noted.

Were the students responses text explicit (Just the facts recited)
Were the responses full of nonessential details? (Not important to understanding the essential message of the passage)
Does the student understand the essence of the passage? (Main idea)

Unless you assess students' comprehension with the intent to learn what students do and do not remember, you can only speculate about their comprehension and the appropriateness of your instructional focus.

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Say Something- 2 students read a passage to a designated point Each has to say something about the reading

Segmented reading --see: Jigsaw

Semantic map--see Mapping and **Webbing**

Sequencing–*Paragraphs*

- Articles are cut into parts based on content.
- Student reads each part
- Student orders the parts based on content

Pictures

- Cartoons or picture sequences are cut apart
- Student orders the part based on content

T Chart – (Johnson & Johnson)Write the name of a skill to be learned or practiced and draw a large T beneath it. Write "looks like" on the left side of the T and "sounds like" on the right side. On the left side list behaviors that one might see in someone exhibiting this skill. On the right side list phrases that might be used by someone exhibiting this skill.

Think aloud- (Davey)Instructor models and tells the thought process for an instructional piece of material.

Three-way rotation–Three different ways of saying the same thing.

Time line-- Events are placed on a time line to visualize the relationship of events in respect to what else was happening at the same time.

Total Physical Response (Asher)--incorporates listening to directions or commands like, "STAND UP!, SIT DOWN!" and they respond to commands without speaking. Used most effectively in early ESL situations.

Transformation- charts, graphs, maps, forms -learn key idea and transform into different format/media Ex. Act out without words Make a chart or form to explain information to others

Webbing-- Similar to semantic mapping - as a graphic representation of the relationships between major ideas and supporting details. After reading, introduce the central question/idea circled on an overhead or chart. Encourage students to identify supporting secondary ideas, which branch off from the central idea. Supporting details are then supplied for the secondary ideas in a logical fashion.

Word bank–a versatile tool for vocabulary learning. Excellent warm up before reading and writing, assessing prior knowledge. Select a topic related to reading. "When I think of _____ I think of _____" Instructor fills in blanks then asks, "What do you think of? Try to generate 25-50 words per topic.

a. Builds critical thinking skills by clustering words that belong together.
b. Try adding prefixes and suffixes. Discuss how changing the form can change meaning.
c. Focus on spelling; note roots and affixes, number of syllables.
d. Plan a writing exercise. Determine organization according to purpose.
   How to = chronology
   Personal experience = narrative
   Description = topic characteristics.
e. Add vocabulary words as they are discovered through reading or conversation

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Instructor's Role and Responsibilities

There are four main responsibilities in your role as instructor of this class.

1. **Instruction** -- As the instructor you will choose the lessons and gauge the depth of instruction based on the needs of your students and the accomplishment of the objectives.

2. **Assessment** -- This vital part of your role should be handled with great sensitivity. Many adults have not been in a classroom setting for a long time. For some, the testing situation and facing the results of tests is an extremely stressful experience that can cause them to drop out of the class. Diffusing the anxiety of the testing situation is a necessary part of your role.

The pretest (Preview) should be giving before instruction begins to gauge the level of your students' understanding and prior knowledge of course content. The posttest (Review) should be given at the end of instruction. Results will be compared to see if instruction made a difference.

If instruction includes fractions, give the pre and post tests that include fractions. If you will not be including fraction lessons, give the pre and post tests without fractions.

Also, the pre and post tests are identical with the exception of the cover page. Make sure the *pre test* uses the *Preview* cover page, and the *post test* uses the *Review* cover page. Subsequent pages are the same.

3. **Keeping attendance records** -- In some work situations, attendance is mandatory. In others, employees are paid to attend and accurate attendance records should be maintained.

4. **Other records** -- Anecdotal comments and observations, especially in regard to learning or change, should be documented. Companies and unions are very interested in this kind of feedback and may want to use quotes for recruitment or promotional activities.

This lesson format encourages you to keep notes on how individual lessons worked and what changes might be made to make the lesson more effective to your particular situation.

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Objectives

The objectives of SPC-Prep 1 are:

- **To demonstrate mastery of addition, subtraction, multiplication, and division of whole numbers, and decimals.**
- **To demonstrate mastery of place value in regard to decimals.**
- **To demonstrate mastery of addition and subtraction of positive and negative numbers.**
- **To calculate an average from a sum of positive and negative numbers.**

The objectives of SPC-Prep 2 are:

- To discuss the changes in the need for quality through history to the present.
    1. The Need for Quality
    2. Changes in the Approach to Quality through History
    3. What is Quality in the Workplace
- To explore the concept of SPC-- What is it? What is involved? How is it accomplished?

    What are Statistics?

    Intro to Statistics

    What is Statistical Process Control?
- To consider the benefits of using SPC for maintaining quality in production as related to customer expectations and/or demands, QS9000.

    QS9000 -- What can customers expect from a supplier's quality system?
- To know and use the appropriate SPC vocabulary.
- To know and apply the major concepts of SPC.
- To read and interpret SPC charts and graphs.
    1. Tables and charts
    2. Graphs
- To apply the necessary math skills in SPC situations.
- To improve reading and writing skills as related to SPC.

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How These Lessons are Organized

Objectives for each course have been identified. Lessons have been designed to assure objectives are accomplished. Lessons are designed in a format that has six parts:

I. Understanding/Outcome

II. Materials

III. Demonstration

IV. Exercise / Engagement

V. Workplace Application

VI. Evaluation / Comments

The following page gives a detailed explanation.

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Explanation of Lesson Format

I. Understanding /Outcome: Focus of the lesson.

Materials: What is needed and helpful to do the lesson. Accompanying supplementary materials: Materials supplied or designed to support the lesson.

III. Demonstration	
Activate prior knowledge. The activation of prior knowledge is a critical piece of the Whole Language philosophy. Lessons will always begin with suggestions for activation of prior knowledge, so students can make a connection to their past experience.	Suggested activities. Examples of possible scenarios or questions to initiate discussions. See *Glossary of Instructional Terms* for more explanation of methods suggested.

IV. Exercise/Engagement:	
A step by step procedure for the lesson. Specific activities to engage the students with instructor supervision. The instructor is provided with this framework with the understanding that adaptations may be made to suit the individual or the group.	1. Suggested activities. See *Glossary of Instructional Terms* for more information.

V. Workplace Application: How this new learning, understanding, or concept is applied in the workplace.

VI. Evaluation/Comments: This space is provided for instructor's commentary and/or evaluation of the level of success of the lesson. This may include the duration of time on task, student comments about the lesson, instructor comments about the lesson, and instructor observations on how to improve, expand, or further customize the lesson.. Initially, this information was used to revise and improve pilot lessons for replicable models of instruction. As instruction continues, it is a valuable way for the instructor to keep track of particular strengths or weaknesses of a lesson, things to remember when teaching, etc.

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Planning and Scheduling

Time Requirements

SPC Prep 1 is dependent on the math backgrounds of students, but typically is designed to provide approximately 24 hours of instruction. SPC-Prep 2 can be interwoven in SPC Prep 1 or taught separately. It is about 12-15 hours of instruction. The format of the course allows the instructor the flexibility to customized lessons to fit the time available. Due to the variability of students' skill levels and interests, the instructor must make many decisions on lesson length and inclusion.

Size of Class

This course can be adapted to work with any size group. If a very large number of participants is scheduled, after initial discussions for activation of prior knowledge, smaller groups should be formed so the instructor can facilitate learning and individual needs can be served.

Expected Outcomes

Participants of this class will improve the skills required to successfully complete SPC training. This course is designed to build a foundation of math skills, vocabulary, and concepts for subsequent SPC training.

Prerequisites

It is assumed that those taking SPC Prep 1 and 2 have the reading ability necessary to read the newspaper or popular magazines. It is also assumed that participants have an understanding of the 4 math operations--addition, subtraction, multiplication, and division. Though math skills must be refreshed when not used for long periods of time, this course assumes that those in the program will only need a review to build on higher math concepts. Much more time will be necessary if participants do not have a reading level that allows them to read the newspaper or if they have not mastered the basic math.

What This Course Won't Do

This class does not specifically address the needs of those who have very limited reading, writing, math skills, and/or difficulty understanding English. It is recommended that participants in this category should be encouraged to seek out ABE (Adult Basic Education) programs in the community or that some arrangement be made to meet with them for individualized instruction.

Suggested Timing for Each Lesson

It is difficult, if not impossible, to give time estimates for lessons. The goal is to suit the lesson to the learners needs. The variables on each topic will include the amount of experience and prior knowledge and the skill levels of the participants. Our experience has shown a time range from 20-75 minutes is workable. Some very difficult lessons may require several sessions.

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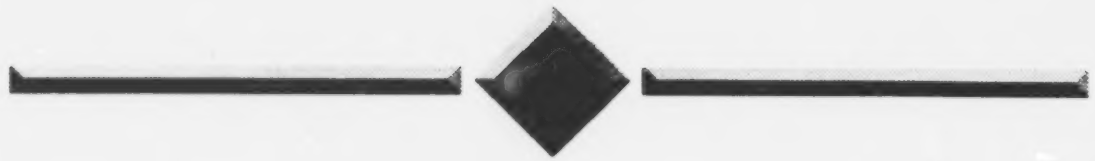
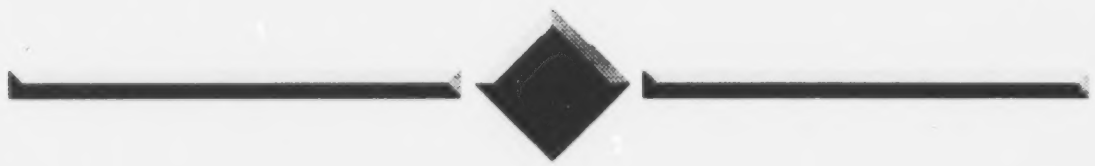


Lessons & Materials



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Math Memories

I. Understanding /Outcome: Building on past experiences to enhance learning

II. Materials: Accompanying supplementary materials: *Math Memories*

III. Demonstration	
Hand out a sample math test and ask students to just LOOK at it a minute or two. Ask them to think about the kinds of feelings that looking at the math test produced.	Suggested activities. Getting rid of 'baggage' is an important step in learning.

IV. Exercise/Engagement:	
Then pass out *Math Memories* sheet. Ask students to complete the sentences. Be sure to clarify that no names should be put on these sheets because it doesn't matter for this exercise. Once *Math Memories* is completed, collect them and shuffle them and redistribute them so everyone reads someone else's. Put labels for 3 categories on the board; *Positive*, *Negative*, and *Neutral*. Based on their own experiences and the other sheets they have read, try to categorize the kinds of math experiences the students in the class have had.	1. This activity is designed to deliberately recapture feelings about school math experiences. Most adults in these math classes have had negative experiences The point of this lesson is to help students recognize that they are not alone in their fears and anxieties about math. By encouraging students to attend to their feelings about math instead of avoid them, it is hoped that feelings of isolation and embarrassment will be reduced and group discussion and sharing will be promoted. (Taken from *The Long Road to Exorcism* by Joy Walker, Good Practice, July 27, 1995. http://www.deet.gov.au/pubs//g_p/gp27/story1.htm)

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V. Workplace Application: Opening lines of communication on sensitive issues can enhance learning in many situations.

VI. Evaluation/Comments:

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No name please.

Math Memories

When I think about math _____.

The best thing about math was _____.

The worst thing about math was _____.

When it comes to math, I was always _____.

The best math teacher I ever had was _____.

The reason s/he was so good was _____.

The worst math teacher I ever had was _____.

The reason s/he was so bad was _____.

When it comes to math, if I knew then what I know now, I would_____

_____.

Whenever I try to do word problems _____.

Math has always seemed to be _____.

When it comes to math, the only thing I'm really sure about is _____

_____.

I'd like to learn about _____.

In my life, I need math to _____.

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Keeping Track of Learning

I. Understanding /Outcome: How to use the SPC-Prep Daily Report

II. Materials: Accompanying supplementary materials: *SPC-Prep Daily Report*

III. Demonstration	
Activate prior knowledge. Have you ever had to keep track of something over a period of time? (Giving medications to a sick person, tracking the performance of a problem, etc.) What is the value of keeping a written record of a process?	Suggested activities.

IV. Exercise/Engagement:	
Ask students to look over the SPC-Prep Daily Report form . Discuss the way the form will be used in class each session.	1.

V. Workplace Application: Keeping written records of progress is valuable.

VI. Evaluation/Comments:

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SPC-Prep Daily Report

Name: _____ Date: _____ Time _____

Today's topic: _____

What I learned today: _____

Why do I need to know this? _____

How did I learn this? _____

What I need more practice with: _____

What would be helpful for me to learn: _____

I am ready to move on to the next topic. ❒ Yes ❒ No

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Introduction to Math Operations

I. Understanding /Outcome:
The use of numbers in the workplace and daily life--practical applications of basic math operations.

Materials: Checkbook, calendar, ruler, catalogue, menu, grocery store advertisement, SPC charts, work-related forms, clock, etc. Chalk board, pencils and paper.

III. Demonstration	
Activate prior knowledge. 1. Introduce use of numbers in daily life. 2. Discuss ways of using number operations during the day--when do you have to add, subtract, multiply or divide?	Suggested activities. 1. Display assorted items. "In what ways have you had to use numbers in the past 24 hours (or week)?" 2. Discuss and list on board, "What did you have to do with these numbers?" Possible responses are count, check date, pay for groceries, fill up gas tank, calculate miles per gallon, etc.

IV. Exercise/Engagement:	
1. Identify basic operations and provide examples of using each operation. 2. Have students decide if they would like to spend time reviewing the 4 operations. 3. Discuss the most common problems with each operation.	1. What math operations did you use in the last week? 2. With a partner, list as many ways as you can think of that you use math. 3. Students may not speak freely about math deficiencies in a group. Give them an opportunity to write about math experiences or

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4. Pretesting basic operations helps students better assess their math skills.	frustrations in their journal so math instruction can be individualized.

V. Workplace Application: Employees must use basic math operations to complete SPC charts (range and average) and to function in everyday life (balance checkbook, figure tips, etc.).

VI. Evaluation/Comments:

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Place Value

I. Understanding /Outcome:
Place value is critical to understanding whole number operations: addition, subtraction, multiplication, and division.

Materials: Tally sticks for ones, tens, hundreds, rubber bands, Handout: Place value chart

III. Demonstration	
Activate prior knowledge. Discuss need for getting in the right line or place. Discuss need for being in the right place.	Suggested activities: 1. Did you ever get in the wrong line when waiting for something (getting tickets, waiting for rides at an amusement park)? 2. Did you ever have to add a column of amounts of money and the numbers were not lined up? (Keeping track of expenses on a trip)

IV. Exercise/Engagement:	
This very basic place value exercise should be used only if students demonstrate they have no concept of place value.)	
1. Use tally sticks to show place value.	1. In pairs have students count out 12 sticks, putting a rubber band around 10 showing 1-ten and 2-ones.
2. Discuss and write random numbers, indicating place value of number. (Use single and double digit numbers with tally sticks)	2. Continue showing numbers with tally sticks and have students write numerals.

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3. Review place value chart	3. Emphasize the need for zero as a place holder writing numbers.
4. Give several examples of whole and decimal numbers.	4. 42, 103, 1.5, 15.3 1002, 10.02

V. Workplace Application: Place value is basic to understanding all math operations used in the workplace.

VI. Evaluation/Comments:

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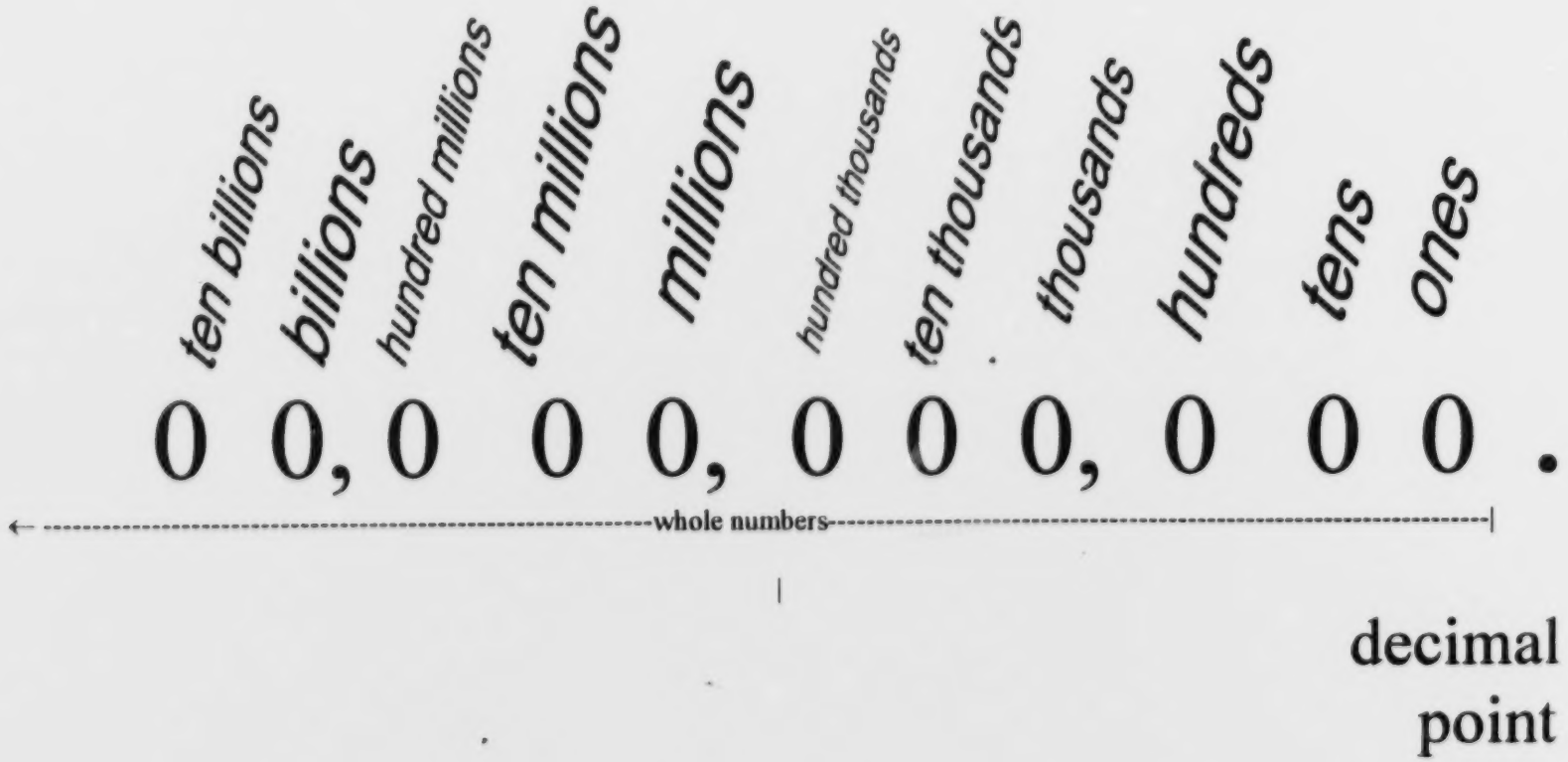
Whole Number Place Value Chart



Whole Number Practice

Add the following:

1.
74
23
80
\+ 22

2.
14
82
51
\+ 46

3.
98
19
97
\+ 73

4.
98
35
49
8
\+ 93

5.
38
95
56
\+ 97

6.
383
558
214
\+ 635

7.
685
378
298
\+ 419

8.
496
545
339
\+ 108

9.
332
479
283
\+ 476

10.
8613
8000
9678
3159
\+ 2718

11.
41263
87190
36850
23367
\+ 70201

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Subtract

1. 71 - 38	**2.** 807 - 216	**3.** 4930 - 1038
4. 5671 - 1084	**5.** 67592 - 48111	**6.** 65758 - 26946
7. 54629 - 20099	**8.** 61287 - 20698	**9.** 21248 - 11447

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Multiply

1. 16 x 20

2. 36 x 77

3. 89 x 99

4. 289 x 998

5. 8736 x 605

6. 2671 x 803

7. 2000 x 701

8. 9503 x 431

9. 10000 x 100

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Divide

1. 36 -:- 12 =

2. 57 -:- 19 =

3. 720 -:- 36 =

4. 26010 -:- 45 =

5. 1288 -:- 23 =

6. 70488 -:- 89 =

7. 1248 -:- 42 =

8. 6272 -:- 24 =

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Rounding Off Numbers

I. Understanding /Outcome: How to round off numbers to a designated place.

Materials: Blackboard, chalk, hand out, paper, pencils, journals Handout:

III. Demonstration	
Activate prior knowledge. 1. Introduce the need for rounding off numbers.	Suggested activities. 1. "If I were pricing a new house that I was interested in buying, I wouldn't tell you it cost $98, 694.26. I would more likely say it was nearly 99 thousand or about 100 thousand." Can you think of other examples of simplifying an exact number? (Federal budget, large hospital bill, estimating cost of home repairs or home improvement.)

IV. Exercise/Engagement:	
1. Provide numbers for learners to round off to a designated place from work or home context. 2. Complete the hand out if concept is unclear or more practice is needed.	1. On the board, write numbers and discuss where they should be rounded off: to the nearest 10, 100, 1000, etc. 2. As a group or in pairs, provide numbers to be rounded off to the nearest _____. 3. Have learner explain procedure for rounding off numbers. 4. Write explanation of process of

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	rounding off in daily log.

V. Workplace Application: Rounding off numbers is a skill needed in some SPC calculations.

VI. Evaluation/Comments:

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Rounding off numbers

We round off numbers to make them easier to understand or when accuracy is not necessary. Auto manufacturers publish reports of the number of cars sold in a given time with rounded off numbers.

If 12,624,723 cars were sold in a 6-month period, the number may be rounded off to the nearest hundred thousand -- 12,600,000.

To round whole numbers, follow these steps:

Underline the number in the place you are rounding.
12,624,723 (6 is in the hundred thousand place)

Look at the number in the next place to the right of the underlined number. 12,624,723 (2 is next to the underlined number in this example.)

If the number to the right is less than 5, leave the underlined number as it is. (2 is less than 5)

If the number to the right of the underlined number is 5 or more, add 1 to the underlined number.

Change all numbers to the right of the underlined number to zero.

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Practice Rounding Off Numbers

1. Round to the nearest 10:

78 _____	53 _____	45 _____
32 _____	985 _____	817 _____
897 _____	432 _____	911 _____

2. Round to the nearest 100:

3,124 _____	6,598 _____	2,912 _____
8,555 _____	8,499 _____	4,150 _____

3. Round to the nearest 1000:

23,798 _____	65,073 _____	98,186 _____
67,599 _____	41,008 _____	99,199 _____

4. Round to the nearest 10,000:

123,456_____	456,987_____	983,129_____
793,108_____	497,296_____	928,376_____

5. Round to the nearest 100,000:

1,497,387 _____	109,477,498_____
8,399,832 _____	986,399,737_____
4,783,925 _____	843,399,000_____

6. Round to the nearest 1,000,000:

123,995,884 _____	165,376,984 _____
974,538,883 _____	170,802,840 _____

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Finding an Average or Mean

I. Understanding /Outcome: How to find the average or mean of a sum of numbers.

II. Materials: Accompanying supplementary materials:

III. Demonstration	
Activate prior knowledge. 1. What is an *average*? 2. What are some examples of averages in everyday life? 3. What is a *mean?*	Suggested activities. 1. Define the term average by getting responses from the group. 2. List responses from group. (Batting averages, average temperatures, test scores in school, etc.) 3. Make sure participants understand that the terms *mean* and *average* are interchangeable.

IV. Exercise/Engagement:	
1. What is the reason for calculating averages? 2. What do you need to know to calculate an average? 3. When are averages used at work? Are they used to track performance and make predictions? 4. Practice averaging sets of data. 5. Elicit scenarios from the workplace to use as examples for practicing finding an average.	1. In many cases it is to track performance and make predictions as in the weather and sports. 2. Try to elicit the *total* of a set of data and the *number of sets* that are in the total. 3. Elicit responses. 4. Refer participants to the *Finding the Average or Mean* 5. For extra practice, see the practice sheet.

V. Workplace Application: Finding the average is a necessary skill in SPC

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calculations.

VI. Evaluation/Comments:

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Finding the Average or Mean

The **average** or **mean** is a good measure to describe the middle amount of a set of data. To find the **average** or **mean,** divide the total by the number of parts.

Example: The East production line produced 100 flywheels during the first shift, 154 during the second shift, and 162 during the third shift. What was the average production for the East line that day?

100 First, find a total of the parts. In this case, the number

154 of parts produced during each shift.

\+ 160

414

414 -:- 3 = 138 Next, divide the total by the number of sets of data. In this case, the total is divided by 3, since there were 3 shifts that produced data.

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Practice with Averages

1. Tim's production of oil pans for the week was:

Monday	98
Tuesday	101
Wednesday	142
Thursday	158
Friday	139

What was his average for the week?

2. On her delivery route, Debbie used 8 gallons of gas on Monday,
10 gallons of gas on Tuesday,
9 gallons of gas on Wednesday,
14 gallons of gas on Thursday,
and 8 gallons of gas on Friday.

What was the average amount of gas used daily?

3. The Advise Company had sales of $103 million in 1990, $142 million in 1991, $98 million in 1992, $112 million in 1993, $138 million in 1994, and $156 million in 1995.

What is their average sales from 1990 to 1995?

What is their average sales from 1990 to 1992?

What is their average sales from 1993 to 1995?

4. Write a problem about finding an average at this company. (You may not do this on your job right now.)

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Introduction to Decimals

I. Understanding /Outcome: Understanding the concept of decimals: how to read and write decimals.

II. Materials: Dollars, pennies, nickels, dimes, quarters, half dollars, completed SPC charts, decimal place value chart, pencils, paper.

III. Demonstration	
Activate prior knowledge. Introduce the concept of decimals.	Suggested activities. 1. If you wrote a check for groceries for $42.36 (write on board), how would you know which numbers represented dollars and which numbers represented cents? (The decimal point separates whole numbers from parts of a whole.) 2. Where else do you use decimals? (SPC charts, balancing checkbook, metric measurements, etc.)

IV. Exercise/Engagement:	
1. Determine place value of numerals with decimal point. 2. Read and write decimals. 3. Discuss decimals used in the workplace. How do different jobs use decimals?	1. Using real dollars and coins, have learners write the amount of money shown. Explain the value of each number written. Use place value chart to reinforce the concept of decimal place value.

V. Workplace Application: Decimals are used on SPC charts, metric measurement, and in daily life situations.

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VI. Evaluation/Comments:

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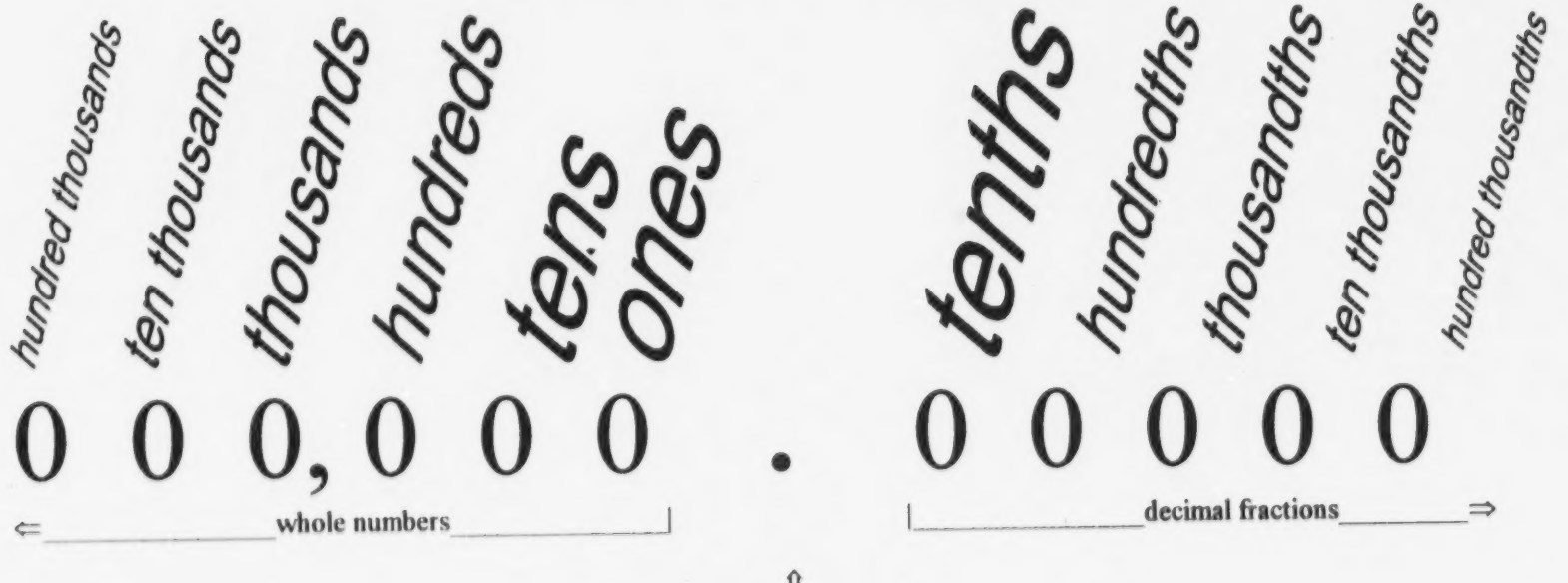
Place Value


hundred thousands
ten thousands
thousands
hundreds
tens
ones
tenths
hundredths
thousandths
ten thousandths
hundred thousandths
0 0 0, 0 0 0 . 0 0 0 0 0
⇐ whole numbers
decimal fractions ⇒
decimal point

Math Operations With Decimals

Add the following:

1. 6.1 + 2.5 + 4.6 =

2. 634.1 + 4.1 + 796.1 =

3. .614 + 3 + 2.8 + 743.1 =

4. 26 + 7.1 + 5 + 0071 =

5. 6.73 + 4 + .0006 =

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Subtract the following decimals:

1. 6.71 - .50 =

2. 38.7 - 2.2 =

3. 47.6 - .40 =

4. 3.7010 - .9624 =

5. 64.7121 - .00375 =

6. 1267.83 - 94632 =

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Multiply the following decimals:

1. 3.7 x 67

2. .36 x 2.6

3. .71 x. 86

4. .893 x .001

5. 783 x .023

6. .471 x .001

Divide the following decimals:

7. 6.9 -:- 2.3 =

8. 32.43 -:- .47 =

9. .3132 -:- .36 =

10. 84 -:- .00021 =

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Add the following decimals.

1. 6.80
+.02

2. 3.4
+ 1.7

3. 2.06
+ 1.1

4. 4.7
.01
.002
+ 3.0

5. 8.71
.121
+ 1.60

6. 3.1 + 2.8 + 4.3 =

7. 2.6 + 4 + .0072 =

8. 4.062 + 2.2 + .007 =

9. .386 + .002 + .5463 =

10. 916.3 + 20.6 + .066 =

11. 4.7 + 1.96 + .001 =

12. .006 + .00046 + 2.2 =

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Subtraction of decimals

1. 9.6 - .002 =

2. 4.76 - 1.25 =

3. 15.6 - 3/3 =

4. 106.78 - 9.9 =

5. 387.1 - 132.26 =

6. .0934 - .0012 =

7. .00065 - .000347 =

8. 967.95 - 2.56 =

9. .0073 - .0028 =

10. .0006 - .00059 =

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Multiply the following decimals.

1. 8.1
X 2.5

2. 2.6
X 1.7

3. 11.9
X .03

4. 1.78 X .21 =

5. .003 X .02 =

6. 175.1 X .00001 =

7. 93.1 X 10 =

8. 33.6 X .002 =

9. .0171 X .363 =

10. .00063 X .0027 =

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Divide the following decimals.

1. .06 -:- 2 =

2. 6 -:- .02 =

3. .06 -:- .02 =

4. 3.60 -:- .06 =

5. .360 -:- .006 =

6. 19.88 -:- .28 =

7. 2.346 -:- 5.1 =

8 3600 -:- .0009 =

9. 2.139 -:- 2.3 =

10. 74.8 -:- .44 =

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Basic Operations Using Decimals

1. A crate manufacturer uses wood that is 2.5 mm thick. To save money he plans to use wood that is 1.75 mm thick. How much thinner will the new wood be?

2. A worn floor at the plant must be covered with 1.5 inch plywood and another layer of .75 inch fiberboard. How thick will the new flooring be?

3. The odometer on Chris's car showed that one route to work was 7.7 miles round trip. Another route was 8.3 miles round trip. What is the difference in miles between routes for a 5 day work week?

4. A sign on a truck delivery door says, "Height limit = 11.5 feet." Sam's truck measures 11.2 feet tall when the tires are low. When the tires are full the truck is another 0.3 feet higher. Does Sam's truck clear the doorway when the tires are full?

5. By how much does Sam's truck clear the doorway when the tires are low?

6. Terry drove for 2.5 hours at an overage speed of 70 mph and for 1.5 hours at an average speed of 50 miles an hour. What is the total of the miles driven?

Answers: 1. .75 mm thinner 2. 2.25 inches thick 3. 3 miles difference 4. No, the truck measures 11.5 feet. 5. The truck clears the door by .03 feet. 6. 250 miles

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Rounding Decimals

To round a decimal is to shorten it or make it easier to read. This is done by discarding the digits (numbers) that are not needed.

Example 1: Eric ears $7.68 for each hour of overtime he works. How much will he earn in 2.4 yours of overtime on Saturday?

Step 1: Solve the problem

$7.68

x 2.4

3072

1536

$18.432 Note that there are 3 decimal places in the answer.

Step 2: To write $18.432 as dollars and cents, we want to keep only 2 digits (numbers) to the right of the decimal point. Because 2 is less than 5, we drop the number and leave the answer as 43 cents.

If the number was 5 or more, you would drop the number and raise the digit to the left by one.

Example: $18.466 would be rounded to $18.47.

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Practice Rounding Decimals:

1. Round to the nearest tenth:

0.32 _____ 0.67 _____ 0.65 _____ 0.81 _____

0.94 _____ 0.58 _____ 0.76 _____ 0.59 _____

2. Round to the nearest one hundredth:

0.321 _____ 0.679 _____ 0.652 _____ 0.818 _____

0.943 _____ 0.587 _____ 0.764 _____ 0.595 _____

3. Round to the nearest thousandth:

0.32191 _____ 0.67982 _____ 0.65237 _____

0.81862 _____ 0.94344 _____ 0.58799 _____

0.76469 _____ 0.59527 _____ 1.38585 _____

4. Round to the nearest ten thousandth:

0.32191 _____ 0.67982 _____ 0.65237 _____

0.81862 _____ 0.94344 _____ 0.58799 _____

0.76469 _____ 0.59527 _____ 1.38585 _____

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Positive and Negative Numbers

I. Understanding /Outcome: Recognize and use negative and positive numbers in basic math operations, charts and graphs.

Materials: Thermometer (or picture of a thermometer) Number lines sheet, sample of SPC chart with positive and negative values.

III. Demonstration	
Activate prior knowledge. Discuss situations where negative numbers vs. positive numbers are used. a. temperatures above/below zero b. feet below sea level c. checkbook balance with insufficient funds.	Suggested activities. 1. What does this mean in numbers? It is ten degrees below zero today. 2. How is this written ? 3. What is meant by a geographic location that is described as 500 ft. below sea level.

IV. Exercise/Engagement:	
1. Use a thermometer to show temperature above and below zero. 2. Display a number line with a zero mid-point. 3. Use a site related example to show how adding and subtracting negative numbers may occur at work.	1. Problem: the temperature is -5 degrees at 10 P.M. By 11 PM it is 3 degrees colder. What is the temperature at 11 PM 2. Discuss the process of adding 2 negative numbers / 2 positive numbers. 3. The required thickness of a part may have positive and negative numbers related to it. If it is too thick it may measure +.04 in. and if it is too thin it may measure -.04 in.

V. Workplace Application: Use positive and negative numbers to chart SPC

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VI. Evaluation/Comments:

NOTE: Be sure to check with those in charge of SPC in the plant to understand how signed numbers are used. In some places, signs are disregarded and numbers are added and averaged to get variance. If that is the case, do not teach this lesson. It will only cause confusion.

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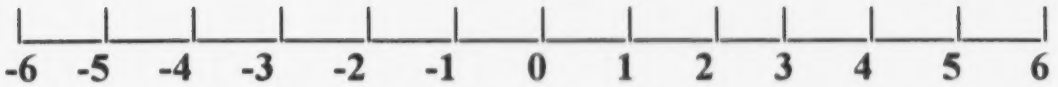
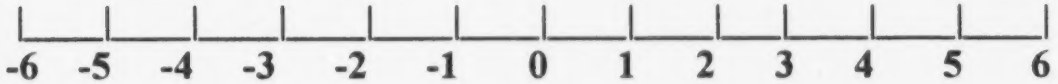
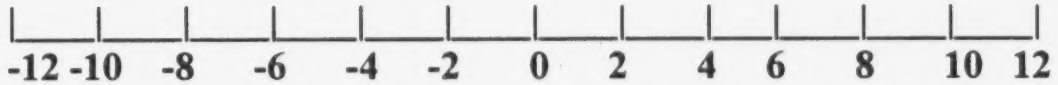
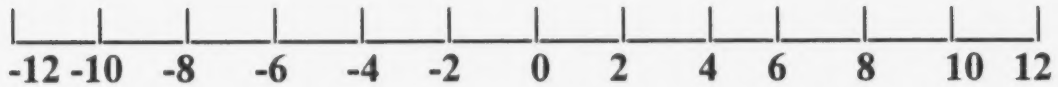
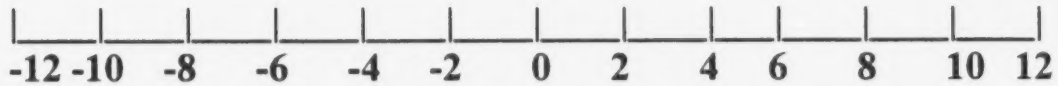
Number Lines

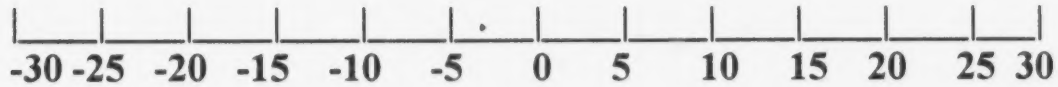


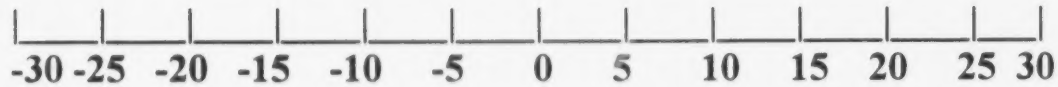


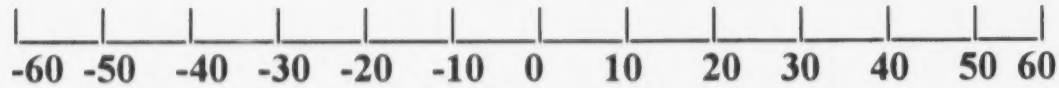


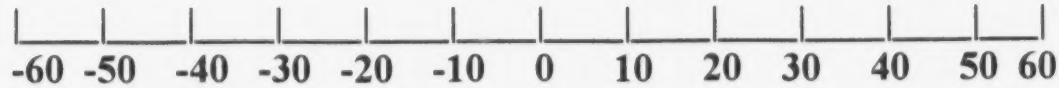












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Rules for Working with Positive and Negative Numbers

Addition Rule 1: To add two or more numbers with the same sign, add the numbers and give the answers the same sign.

Example: The X Company lost $50,000 in sales in May and $10,000 in sales in June. What was the total loss for Many and June?

$$\begin{array}{r} -\$50{,}000 \\ +\ -\$10{,}000 \\ \hline -\$60{,}000 \end{array}$$

Addition Rule 2: To add numbers with different signs, find the difference between the numbers. Then give the answer the sign of the larger number.

Example: Yesterday morning at 6 AM the temperature was 10 degrees below zero. By noon, the temperature at risen 12 degrees. What was the temperature at noon?

$$\begin{array}{r} -10 \\ +12 \\ \hline +2 \end{array}$$

Subtraction Rule: Change the sign of the "take away" number (the second number in the problem), and follow the rules for addition.

Example: The temperature at noon was -3 degrees. It was -18 degrees at midnight. What was the difference between the noon and the midnight temperature?

First write the problem.

$$\begin{array}{r} -3 \\ -\ -18 \\ \hline \end{array}$$

Change the subtraction sign to an addition sign. Also change the number after the subtraction sign to the opposite sign.

$$\begin{array}{r} -3 \\ +\ +18 \\ \hline \end{array}$$

15 degrees difference

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Addition and Subtraction with Positive and Negative Numbers

1. $+5 + (-1) =$

2. $-12 + (-31) =$

3. $+14 + (-8) =$

4. $-10 - (+3) =$

5. $-3 - (-8) =$

6. $+9 - (+6) =$

7. $+16 - (-11) =$

8. $+6 - (-17) =$

9. $0 - (-2) =$

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Rule for Adding 3 or more Signed Numbers

To add 3 or more signed numbers, add the positive numbers. Add the negative numbers. Then add the two totals and give the answer the sign of the largest number.

Example: $9 + (-10) + (-4) + 3 =$
Add the positive numbers $9 + 3 = 12$
Add the negative numbers $-10 + (-4) = -14$
Add the totals together $12 + (-14) = -2$

1. $-8 + (-2) + 6 =$

2. $4 + (-1) + (-3) =$

3. $-6 + 4 + (-10) =$

4. $12 + (-7) + (-7) =$

5. $-22 + (-4) + 3 + 9 =$

6. $40 + (-10) + (-20) + 10 =$

7. $10 + (-25) + 25 + (-16) =$

8. $-20 + (-19) + (-14) + 8 =$

9. $49 + (-54) + 6 + 9 =$

10. $-22 + (-8) + (-7) + 32 =$

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Multiplication & Division Rules with Signed Numbers

Multiplication and Division Rule 1: When you multiply or divide numbers with the **same** sign, give the answer a POSITIVE (+) sign.

Example $-6 \times -3 = +18$ $+6 \times +3 = +18$

$-10 \div -2 = +5$ $+10 \div +2 = +5$

Multiplication and Division Rule 2:

When you multiply or divide numbers with **different** signs, give the answer a NEGATIVE (-) sign.

Example: $-5 \times +8 = -40$

$-24 \div +3 = -8$

$+24 \div -3 = -8$

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Practice Multiplying and Dividing Signed Numbers

1. (-2) (3) =

2. -5 (4) =

3. -9 (0) =

4. -7 (2) =

5. (4) (-25) =

6. -21 -:- -3 =

7. 12 -:- 6 =

8. -18 -:- -3 =

9. -27 -:- 9 =

10. -14 -:- -7 =

11. 70 -:- 10 =

12. -81 -:- 9 =

13. -45 -:- -9 =

14. -16 -:- 2 =

15. 100 -:- -25 =

16. -28 -:- -7 =

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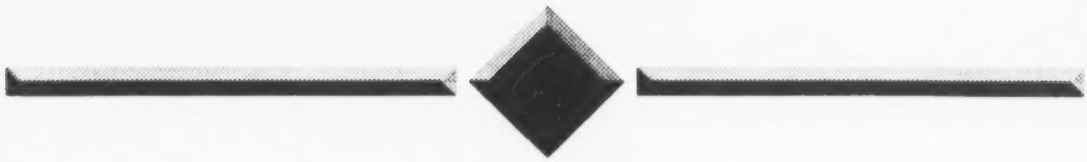

Supplementary Lessons

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Introduction to Fractions

I. Understanding /Outcome:
Fractions are parts of a whole; understanding the numerator and denominator.

II. Materials:
Pita bread (one for each), apples, whole graham crackers, knives, or cardboard circles and scissors.

III. Demonstration	
Activate prior knowledge. 1. Introduce the concept of breaking a whole into parts.	Suggested activities. 1. When you get a pizza, it is usually cut into equal slices. If you have a pie or cake, how is it usually divided? (Equal parts) 2. What other things are usually divided into equal parts?

IV. Exercise/Engagement:	
1. Give hands on experience with dividing wholes into fractional parts.	1. Give each pair of learners a pita, apple, graham cracker, and a knife. Have them divide the whole items into equal parts. With each divided item, have them indicate the whole (ex. 4/4) and parts of a whole (ex. 3/4).
2. Discuss the concept of *fraction*-- parts of whole.	2. How would you write the number to show a part of the whole?
3. Introduce *numerator* and *denominator*.	3. Explain that the numerator tells how many parts and the denominator

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4. A discussion of equivalent fractions may follow to show that 2/4 is equal to 1/4 or 4/8. 5. Discuss when employees use fractions in the workplace.	shows how many parts the whole was divided into.

V. Workplace Application: Understanding fractions is necessary in reading measurements and other workplace applications.

VI. Evaluation/Comments:

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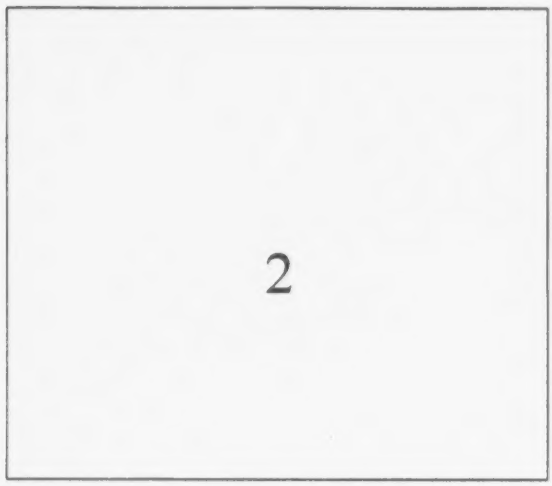
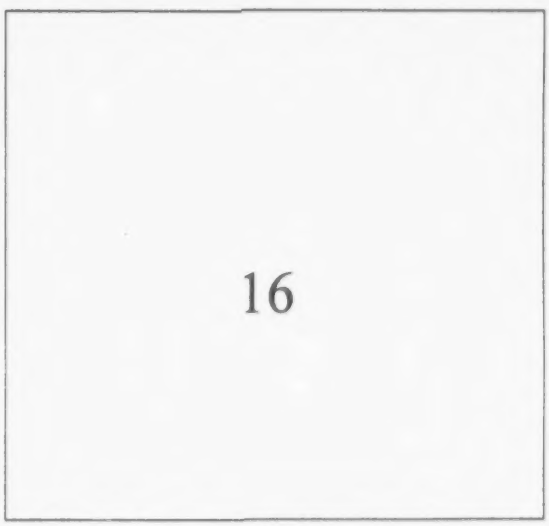
Fractions

Divide the boxes below into the number of equal parts stated in the box.





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Fractional equivalents: Using the boxes on the last page, answer the following questions.

1. How many fourths are there in one half? _____

2. How many eighths are there in one half? _____

3. How many sixteenths are there in one fourth? _____

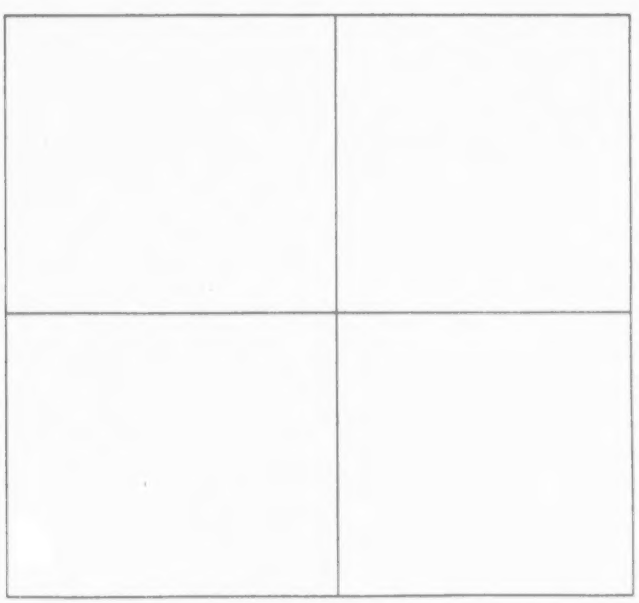
4. How many sixteenths are there in three fourths? _____

5. How many sixteenths are there in one half? _____

$\frac{1}{2} = \frac{2}{4} = \frac{4}{8} = \frac{8}{16}$

6) add $\frac{1}{4} + \frac{1}{4}$

Shade in your answer.



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Practicing Basic Operations with Fractions

Math operations with fractions. Add the following fractions. Be sure to reduce your answer to the lowest terms.

1. $\frac{1}{2} + \frac{1}{2}$

2. $\frac{2}{3} + \frac{1}{3}$

3. $\frac{1}{5} + \frac{1}{5}$

4. $\frac{1}{9} + \frac{4}{9}$

5. $\frac{1}{8} + \frac{3}{8}$

6. $1\frac{1}{7} + 2\frac{1}{7}$

7. $3\frac{1}{4} + 1\frac{1}{4}$

8. $4\frac{1}{11} + 1\frac{2}{11}$

9. $9\frac{6}{15} + 2\frac{3}{15}$

10. $3\frac{1}{4} + 1\frac{1}{4}$

11. $3\frac{3}{8} + 2\frac{1}{8}$

12. $6\frac{1}{14} + 2\frac{1}{14}$

13. $12\frac{7}{8} + 11\frac{5}{8}$

14. $4\frac{4}{5} + 2\frac{3}{5}$

15. $3\frac{1}{8} + 6\frac{7}{8}$

16. $9\frac{1}{8} + 6\frac{7}{8} + 2\frac{5}{8}$

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Common Denominators

Write a common denominator for the following fractions:

1. $\frac{1}{2}$ $\frac{1}{4}$ _____

2. $\frac{1}{3}$ $\frac{1}{9}$ _____

3. $\frac{1}{4}$ $\frac{1}{6}$ _____

4. $\frac{1}{9}$ $\frac{1}{6}$ _____

5. $\frac{1}{5}$ $\frac{1}{10}$ _____

6. $\frac{1}{3}$ $\frac{1}{4}$ $\frac{1}{6}$ _____

7. $\frac{1}{5}$ $\frac{1}{10}$ $\frac{1}{20}$ _____

8. $\frac{1}{7}$ $\frac{1}{9}$ $\frac{1}{3}$ _____

9. $\frac{1}{9}$ $\frac{1}{3}$ $\frac{1}{6}$ _____

10. $\frac{1}{12}$ $\frac{1}{5}$ $\frac{1}{3}$ _____

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Practice with Mixed Fractions

Add the following mixed fractions. Reduce your answer to the lowest possible terms.

1. $6\frac{1}{2} + 2\frac{1}{3}$

2. $2\frac{1}{4} + 1\frac{1}{8}$

3. $7\frac{1}{4} + 3\frac{1}{6}$

4. $9\frac{1}{5} + 1\frac{1}{10}$

5. $7\frac{1}{8} + 1\frac{1}{6}$

6. $8\frac{1}{4} + 1\frac{1}{2}$

7. $12\frac{1}{2} + 8\frac{1}{6}$

8. $14\frac{3}{7} + 12\frac{1}{3}$

9. $14\frac{9}{10} + 11\frac{4}{5}$

10. $17\frac{1}{8} + 12\frac{1}{3}$

11. $19\frac{3}{5} + 12\frac{7}{8}$

12. $23\frac{9}{10} + 10\frac{4}{6}$

13. $15\frac{4}{5} + 10\frac{11}{15}$

14. $35\frac{1}{7} + 12\frac{1}{9}$

15. $1\frac{1}{2} + 2\frac{1}{6} + 1\frac{1}{3}$

16. $11\frac{2}{7} + 8\frac{1}{3} + 4\frac{1}{6}$

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Subtract these fractions. Reduce your answer to the lowest possible terms.

1. $3\frac{1}{4} - 1\frac{3}{4}$

2. $4\frac{1}{6} - 1\frac{5}{6}$

3. $2\frac{1}{9} - 1\frac{5}{9}$

4. $6\frac{1}{7} - 4\frac{3}{7}$

5. $12\frac{1}{9} - 6\frac{4}{9}$

6. $13\frac{1}{14} - 12\frac{5}{14}$

7. $12\frac{1}{25} - 11\frac{7}{25}$

8. $14\frac{1}{7} - 10\frac{2}{7}$

9. $7\frac{9}{16} - 2\frac{1}{3}$

10. $15 - 1\frac{1}{4}$

11. $36 - 5\frac{1}{9}$

12. $7\frac{1}{16} - 2\frac{5}{64}$

13. $12\frac{1}{4} - 6$

14. $7 - 2\frac{1}{4}$

15. $7\frac{1}{4} - 5\frac{3}{8}$

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Subtract these fractions. Reduce your answer to the lowest possible terms.

1. $3\frac{2}{5} - 1\frac{1}{5}$

2. $4\frac{1}{2} - 1\frac{1}{6}$

3. $9\frac{7}{8} - 2\frac{7}{8}$

4. $12\frac{5}{6} - 8\frac{1}{6}$

5. $9\frac{4}{5} - 2\frac{1}{10}$

6. $11\frac{3}{4} - 3\frac{1}{6}$

7. $4\frac{7}{8} - 1\frac{1}{3}$

8. $12\frac{8}{15} - 1\frac{1}{3}$

9. $7\frac{2}{3} - 1\frac{5}{6}$

10. $12\frac{3}{5} - 1\frac{7}{10}$

11. $178\frac{4}{5} - 51\frac{1}{3}$

12. $52\frac{3}{8} - 16\frac{23}{32}$

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Divide the following fractions. Reduce your answer to the lowest possible terms.

1. $\frac{1}{2}$ -:- $\frac{1}{2}$ =

2. $\frac{1}{3}$ -:- $\frac{1}{3}$ =

3. $\frac{3}{4}$ -:- $\frac{2}{3}$ =

4. $\frac{3}{8}$ -:- $\frac{1}{2}$ =

5. $\frac{7}{8}$ -:- $\frac{3}{5}$ =

6. $\frac{7}{12}$ -:- $\frac{1}{3}$ =

7. $\frac{3}{4}$ -:- $\frac{4}{7}$ =

8. $\frac{5}{12}$ -:- $\frac{5}{6}$ =

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Basic Operations with Mixed Fractions

1. Fred has the following lengths of 1 / 2 -inch copper pipe: $8\frac{5}{16}$ inches, $12\frac{1}{2}$ inches, $9\frac{3}{4}$ inches, and 26 inches. If he welds together the three shortest lengths, what will be the length in inches of this new piece of pipe?

A. $28\frac{7}{16}$

B. $30\frac{9}{16}$

C. $29\frac{1}{4}$

D. $28\frac{11}{16}$

2. Fred works for Davis Tool as a truck driver. His delivery route is tabulated each day. Last Friday he drove $10\frac{1}{2}$ miles for his first stop, $14\frac{6}{10}$ miles for the second stop, and $1\frac{3}{10}$ of a mile for the third stop. How many miles did he drive all together?

A. $25\frac{1}{2}$

B. $26\frac{7}{10}$

C. $26\frac{2}{5}$

D. $26\frac{1}{2}$

3. The following Friday Fred drove the same amount of miles (see problem 2) but he took the truck to the garage at the end of the day. The garage was 6 1/5 miles from his last stop on that day. How far did he have to drive?

A. $31\frac{2}{5}$

B. $33\frac{4}{5}$

C. $32\frac{3}{5}$

D. $32\frac{1}{5}$

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4. The factory needed new security fencing around the plant. The land around the factory measured $3\frac{7}{10}$ miles on each of its four sides. How many miles of security fencing is needed to replace the old fencing?

A. $14\frac{1}{5}$ miles of fencing

B. $13\frac{8}{10}$ miles of fencing

C. $12\frac{3}{10}$ miles of fencing

D. $14\frac{8}{10}$ miles of fencing

5. The value of Davis stock went from $19\frac{3}{8}$ to $21\frac{1}{4}$ between June 1 and June 30. How many points in value did the stock change during the month of June?

A. $\frac{7}{8}$

B. $1\frac{1}{4}$

C. $1\frac{3}{8}$

D. $1\frac{7}{8}$

6. New rods for the welding machine had to be cut. One rod measured $10\frac{5}{16}$ and the other rod measured $5\frac{7}{8}$. What is the difference in length between the two rods?

A. $4\frac{7}{16}$

B. $5\frac{7}{16}$

C. $4\frac{3}{16}$

D. $5\frac{3}{16}$

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7. The factory classroom needed to be painted. Tim mixed 5/6 of a pint of thinner in each gallon of paint he used. How many pints of thinner did Tim use to complete the job that requires 24 gallons of paint?

A. 18 pints
B. 20 pints
C. $18\frac{5}{6}$ pints
D. 22 pints

8. The hilo-driver clocks the distance traveled each day. He works 8 hours and drives $31\frac{7}{10}$ miles each day. How many miles does he drive each 5 day week?

A. 158 miles
B. $160\frac{7}{10}$ miles
C. 159 miles
D. 125 5/7 miles
E. None of these

9. If an oil drip pan weighed 10 1/2 pounds how many could you cut from an 840 pounds of steel (do not be concerned about scrap pieces) ?

A. 91 drip pans
B. 80 drip pans
C. 84 drip pans
D. 108 drip pans

10. If one box holds 14 machine brackets, how many boxes are needed to pack 430 machine brackets ?

A. 30 boxes
B. 42 boxes
C. 31 boxes
D. 45 boxes

Answers: 1. b $30\frac{9}{16}$. 2. c $26\frac{2}{5}$ 3. c. $32\frac{3}{5}$ 4. a $14\frac{1}{5}$ miles of fencing 5. d $1\frac{7}{8}$ 6. a $4\frac{7}{16}$ 7. b 20 pints 8. 125 5/7 miles 9. 80 drip pans 10. 31 boxes

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Changing Fractions to Decimals

Write each fraction as a decimal.

1. $\frac{1}{10}$ = _____

2. $\frac{1}{100}$ = _____

3. $\frac{1}{1000}$ = _____

4. $\frac{1}{10,000}$ = _____

5. $\frac{1}{100,000}$ = _____

Write each decimal as a fraction.

6. .7 _____

7. .07 _____

8. .007 _____

9. .0007 _____

10. .00007 _____

11. .000007 _____

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Write each fraction as a decimal.

12. $\frac{23}{100} =$ _____

13. $\frac{8}{10} =$ _____

14. $\frac{7}{10{,}000} =$ _____

15. $\frac{475}{10{,}000} =$ _____

16. $\frac{32}{100} =$ _____

17. $\frac{6750}{10{,}000} =$ _____

18. $\frac{3}{10{,}000} =$ _____

19. $\frac{4}{1000} =$ _____

20. $\frac{6}{10{,}000} =$ _____

21. $\frac{95}{1000} =$ _____

22. $\frac{787}{10{,}000} =$ _____

23. $\frac{65}{100.000} =$ _____

24. $\frac{2}{100{,}000} =$ _____

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Changing Fractions to Decimals and to Percents.

1. $\frac{1}{2}$ = .50 50%

2. $\frac{1}{4}$ = _____ _____

3. $\frac{1}{5}$ = _____ _____

4. $\frac{1}{8}$ = _____ _____

5. $\frac{2}{5}$ = _____ _____

6. $\frac{5}{8}$ = _____ _____

7. $\frac{9}{10}$ = _____ _____

8. $\frac{7}{12}$ = _____ _____

9. $\frac{7}{8}$ = _____ _____

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10. $\frac{1}{3}$ = _____ _____

11. $\frac{2}{3}$ = _____ _____

12. $\frac{1}{6}$ = _____ _____

13. $\frac{4}{5}$ = _____ _____

14. $\frac{3}{16}$ = _____ _____

15. $\frac{9}{20}$ = _____ _____

16. $\frac{4}{25}$ = _____ _____

17. $\frac{7}{25}$ = _____ _____

18. $\frac{17}{20}$ = _____ _____

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Changing Decimals to Fractions and to Percents

Change to a **fraction in lowest terms** and a **percent.**

1.	.40	$\frac{40}{100} = \frac{4}{10} = \frac{2}{5}$	40%
2.	.60	_____	_____
3.	.5	_____	_____
4.	.65	_____	_____
5.	.065	_____	_____
6.	.8	_____	_____
7.	.28	_____	_____
8.	.12	_____	_____
9.	.012	_____	_____
10.	.783	_____	_____

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Finding % of a Whole

I. Understanding /Outcome: Finding % of a whole number

II. Materials: Newspaper ads for discounts, menus, calculator, paper and pencil. Supplementary materials:

III. Demonstration	
Activate prior knowledge. Introduce concept of percentage of a whole.	Suggested activities. 1. Have you ever gone to a store close-out sale where the first week, everything is 10% off, the second week--20% off, the third week 30% off, the 4th week 50% off, and the last week 75% off? When it says 10% off, what does that mean? (% off regular price) Where else have you see % or need to understand % of a whole? (Figuring a tip)

IV. Exercise/Engagement:	
Practice finding percentage of a whole using newspaper ads or figuring tips from meals based on a menu. Reinforce with supplementary materials if needed. Discuss problems using suggestions from learners' strategies.	1. If a sale starts 30% off items, how do you determine what the cost will be? 2. Discuss in pairs, how to change percentages to decimals and then multiply. Continue with examples.

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V. Workplace Application: Finding percentages is a necessary skill used in SPC calculations and also used when figuring out pay deductions and waste tracking.

VI. Evaluation/Comments:

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Finding the Percentage of a Whole Number.

1. 5% of 100 = _____

2. 10% of 80 = _____

3. 16% of 80 = _____

4. 35% of 95 = _____

5. 30% of 600 = _____

6. 75% of 400 = _____

7. 60% of 36 = _____

8. 28% of 56 = _____

9. 19% of 400 = _____

10. $66\frac{2}{3}$% of 300 = _____

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Word List for SPC-Prep 1

abbreviation: a short way of writing something. The abbreviation for Quality Control is QC.

average - the average of a set of numbers is found by adding a set numbers together and dividing by the amount of numbers that make up the sum.
Ex. 12 + 14 + 15 + 19 = 60 60 -:- 4 = 15

axes - the plural of *axis*, more than one axis

axis -- the line on a graph, there are usually 2 axes, one horizontal (left to right) and one vertical (up and down)

bar graph -- a graph that uses bars (stripes or bands) to picture the relationships among numbers. Bar graphs show data based on a vertical axis and a horizontal axis in the form of bars. They are very good for comparing information.
basic operations

basic math signs and operations -

+ addition or positive number
- subtraction or negative number
x multiplication or unknown number
/ division
-:- division
> greater than
< less than

canceling- a shortcut when multiplying fractions. It means dividing a top and a bottom number by a figure that goes evenly into both before actually multiplying. It is not necessary to cancel to get the right answer, but it makes multiplying easier.

chart -- a graphic representation of data that lists exact numbers in columns and rows

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common denominator

chart -- a graphic representation of data that lists exact numbers in columns and rows

column -- a group of numbers or words that are listed vertically, (up and down) in a table or chart

convert - change, Ex. *convert* a fraction to a decimal means to change a fraction to a decimal

communication -- the process of sending a message through selected channels to a receiver and then getting feedback to check for mutual understanding.

communication skills -- The way we give information to others and receive information from others. Reading, writing, speaking, and listening are communication skills.

compare -- to look at two or more numbers and see their similarities and differences; also to decide which is larger or smaller.

convert -- to change one thing to another. Sometimes it's necessary to convert meters to yards.

decimal

decimal point - a dot written in a series of numbers that has the places of whole numbers to the left of it and decimal places to the right of it.

denominator - the bottom number of a fraction, it wills how many parts are in the whole

digit

dimensions -- the length, width, and/or depth of an object. The dimensions of the sheet of steel were: length, 10 feet; width, 5 feet

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divisible number

equal - being the same or identical to in value

fraction -- a part of a whole, a number less than one but greater than zero
Ex. $\frac{1}{4}$

- **graphs** - a picture or map of numbers, tools for displaying data. There are many different kinds of graphs including bar graphs, line graphs, and pie charts or circle graphs.

higher terms - to change a fraction to larger numbers so you can continue with adding, subtracting, multiplying and dividing. $\frac{1}{5}$ can be raised to $\frac{2}{10}$ or $\frac{20}{100}$

improper fraction - the top number is *equal to or larger than* the bottom number.

intersect -- to meet and cross at a point, in a chart or table

invert - means to turn a fraction upside down. $\frac{7}{10}$ can be inverted to $\frac{10}{7}$

lowest terms - to change a fraction to the lowest numbers possible. $\frac{2}{8}$ can be reduced to the lowest terms of $\frac{1}{4}$.

math operations - are addition, subtraction, multiplication, and division

mean - the average of a set of numbers, calculated by adding a set numbers together and dividing by the number of sets in the sum. Ex. 12 + 14 + 15 + 19 = 60 60 -:-4 = 15

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metric system -- a system of measurement based on tens, used by most people outside the Untied States. Unites such as centimeters, millimeters, grams, and kilograms are used in the metric system

minus sign (-) - The sign for subtraction or a negative number

mixed numbers - a whole number written next to a proper fraction, $3\frac{1}{3}$. To perform math operations to some mixed numbers, they must be changed to improper fractions.

$3\frac{1}{3}$ is changed to $\frac{10}{3}$.

multiplication sign (x) - the sign for multiplication.

negative number - a number less than zero

numerator - the upper number of a fractions, it tells how many parts you have

proper fraction the top number is less than the bottom number -- $\frac{1}{3}$

plus sign (+) - the sign for addition or a positive number

positive number - a number greater than zero

reduce (a fraction) - means writing it with smaller numbers. $\frac{25}{100}$ can be reduced to $\frac{1}{4}$

relationship -- a connection between people or things. Graphs and charts show the relationships of numbers

rounding off -

SPC -- Statistical Process Control is a method companies use to achieve quality; a method of gathering and analyzing data to solve practical quality

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problems. Controlling the process with statistical methods to guide in the outcome of quality products or parts whole numbers

statistics -- summaries of data; the science of collecting, organizing, and analyzing data to draw conclusions

table -- a graphic representation of data that lists exact numbers in columns and rows

technology -- Machines and ways of doing things that improve the speed and/or quality of work. The use of computers in manufacturing is an example of modern technology.

U. S. customary units -- the way people in the United States usually measure, using units such as inches, feet, miles, ounces, and pounds. In many industries, U. S. customary units are being replaced by the metric system.

whole numbers - the numbers most commonly used in counting (0, 1, 2, 3, 4, . . .)

width -- the distance from one side to another of something. In rectangles, the shorter dimension. The length of the rectangle was 50 centimeters, the width was 20 centimeters

x - the sign for multiplication. Can also stand for an unknown number.

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Glossary for SPC

- = noted by QC expert to be important terms for Davis SPC training

abbreviation: a short way of writing something. The abbreviation for Quality Control is QC.

accuracy -- the amount of error in a measurement in proportion to the total size of the measurement, the degree to which an accomplishment matches a model without errors of omission or commission.

- **assignable variations** -- variations in data which can be attributed to specific causes, such as machine function, atmospheric conditions

- **attribute data**-- information that comes from counting the number of good or bad items in a group like the number of defective pieces in a lot, the number of surface scratches on a fender, or the number of broken pins in an electrical component. Refers to data with measurement characteristics which can be easily assigned a numerical value (quantifiable).

attribute sampling -- characteristic, inspecting then classifying, difficult to assign numerical values to

axis -- the line on a graph, there are usually 2 axes, one horizontal (left to right) and one vertical (up and down)

bar graph -- a graph that uses bars (stripes or bands) to picture the relationships among numbers. Bar graphs show data based on a vertical axis and a horizontal axis in the form of bars. They are very good for comparing information.

baseline data -- performance measurement taken before trying a new method or technique

bunching -- a group of similar measurements occurring quite close together on a pattern

C-charts -- charts utilized to plot the percentage of defects per sample

chart – a graphic representation of data that lists exact numbers in columns and rows.

circle graph -- a graph where the circle represents the whole and the pie-shaped pieces show the different sizes of the parts, often expressed in % and the parts add up to 100%, also called a pie chart.

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column -- a group of numbers or words that are listed vertically, (up and down) in a table or chart

communication -- the process of sending a message through selected channels to a receiver and then getting feedback to check for mutual understanding.

communication skills -- The way we give information to others and receive information from others. Reading, writing, speaking, and listening are communication skills.

compare -- to look at two or more numbers and see their similarities and differences; also to decide which is larger or smaller.

conformance to specification -- the formal definition for Quality

- **control specifications** -- specifications called for by the product being manufactured.

convert -- to change one thing to another. Sometimes it's necessary to convert meters to yards.

corrective action -- the process of correcting problems when the preventive approach is not used or does not work. this is the most expensive way to remedy problem situations.

customers -- those inside and outside an organization who depend on the output of your efforts. They receive the work that you complete.

cycle-- a pattern that begins to repeat itself on a control chart, short trends in data which occur in repeated patterns

- **data** -- the collection of numbers that gives us information about a subject: factual information (as measurements or statistics) used as a basis for reasoning, discussion and calculation

data entry system -- a way of getting information into a computer. Today, many manufacturing workers must learn how to operate data entry systems.

dimensions -- the length, width, and/or depth of an object. The dimensions of the sheet of steel were: length, 10 feet; width, 5 feet.

- **distributions** -- tendency of large numbers of observations to group themselves around some central value with a certain amount of variation or "scatter: on either side.

exceed limits -- a point located outside either upper or lower control limits

exterior dimensions -- the dimensions on the outside of a shape.

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fluctuations -- variances in data which are caused by large number of minute variations or differences

- **freaks/outliers** -- a pattern resulting from a single unit or single measurement which differs greatly from the others.

- **frequency distribution** -- the pattern or shape formed by the group to measurements in a distribution; a tabular summary of a set of data showing the frequency, or number of observations, of a particular value or within a specified group

global economy -- the way business and manufacturing are tied together all over the world. Most manufacturing is done as part of the global economy.

- **gradual change in level**-- the data on a graph indicating a trend which consistently moves either above or below the center line.

- **graphs** - a picture or map of numbers, tools for displaying data. There are many different kinds of graphs including bar graphs, line graphs, and pie charts or circle graphs.

- **grouping** -- a group of similar measurements occurring quite close together on a pattern

heading -- a label for columns and rows that describes the information provided in a chart or graph

- **histogram** -- vertical display of a population distribution. A formal way of plotting a frequency distribution of observed values by writing a series of columns, each having a width equal to the cell width; a chart representing statistical data by rectangles whose widths represent class intervals and whose heights usually represent corresponding frequencies.

- **horizontal axis** -- the line on a graph or control chart that goes from left to right across the page

initials -- the first letters of words or names. Sometimes charts have initials on them to show who collected the data.

input -- in manufacturing, the machines, equipment, methods, material, personnel, and environment are all considered *input*

- **instability** -- abnormally large fluctuations in a pattern on a control chart

interaction -- the tendency of two or more variables to produce an effect in combination which neither variable would produce if acting alone

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intersect -- to meet and cross at a point, in a chart or table

- **line charts** -- charts used to track the performance without relationship to process capability or control limits

line graphs -- a graph that uses a line to show the relationships among numbers. Line graphs have information on both a vertical axis and a horizontal axis. They are used for displaying trends or patterns or time. Points are plotted on the graph and lines are drawn to connect them.

- **lower control limit** -- a horizontal dotted line plotted on a control chart which represents the lower process limit capabilities of a process

manufacturing – making or processing something with machinery. Manufacturing cars is big business in the United States.

metric system – a system of measurement based on tens, used by most people outside the Untied States. Unites such as centimeters, millimeters, grams, and kilograms are used in the metric system

- **n** -- the number of observations in a group or set, often referred to as a sample size

- **natural pattern** -- a pattern formed by the natural tendency of the population to group around a central point. It means that there are no abnormal extraneous causes working in the process.

Nonconformance -- not meeting the specified requirements.

100% inspecting/testing -- an inspection technique in which the total population is inspected.

observation – a single data value in a sample
a group of similar measurements occurring quite close together on a pattern

overview -- a short general statement that begins a report, book, or manual, that gives the general ideas or points to the reader.

- **p charts** -- charts utilized to plot percent defectives in -- a sample

- **Pareto** -- a chart which ranks, or places in order, most common occurrences

pie chart -- a graph where the circle represents the whole and the pie-shaped pieces show the different sizes of the parts, often expressed in % and the parts add up to 100%, also called a circle graph

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- **population** -- term used to describe the total of all items, all possible items of interest

precision -- refers to the differences among repeated measurements.

prevention -- anticipating and eliminating potential errors before they occur

probability -- the chance of something happening, the percent or number of times something should occur over a large number of trials, when we say a 10% probability of rain, this means it should rain on 10 out of every 100 days when the same atmospheric conditions occur.

- **process** -- any set of conditions or set of causes working together to produce and outcome. The changing of the *input* into the *output* is the process, so the changing of a coil of flat steel into a large amount of oil pan covers is a *process*.

process control chart. -- any number of various types of graphs upon which data are plotted against specific control limits

projection -- a prediction based on past and current trends

quality -- the total of features and characteristics of a product or service that bears on its ability to satisfy given needs; meeting the customer needs and expectations; (To satisfy given needs means that we must be able to identify the features and characteristics of products that customers want.)

quality assurance -- working in a way that makes sure a product is made the way it is supposed to be made or meets certain standards; it begins before production starts and continues until the product is in the customer's hands.

- $\bar{R}$ (R bar) --the average of ranges, a unit of measure which is used to describe the width or spread of a distribution or pattern; the fluctuations in a 'natural' pattern tend to spread about plus or minus 3 (also known as standard deviation)

- **R charts** -- plot the difference between the highest and lowest in a sample; range control chart

- **R (range)** -- the difference between the largest and smallest measurements in a sample; absolute value, always a positive number

- **random** -- selecting a sample so each item in the population has an equal chance of being selected

- **random variations** -- variation in data which result from causes which cannot be pinpointed or controlled

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ratio-- the relative size of 2 quantities express as the quotient of one divided by the other. The ratio of 7 to 4 is written as 7:4 or 7/4.

relationship – a connection between people or things. Graphs and charts show the relationships of numbers.

requirements – everything (attributes, features and benefits) the customer expects to receive with the product. Your customer, a co-work, supervisor, or another department may set requirements

rework – doing something at least one extra time due to nonconformance to requirements.

row -- a group of numbers or words that are listed horizontally (across from left to right) in a chart or table.

run -- 7 or more consecutive points above or below the center line on a control chart

- **sample** -- a portion of the population that is selected to represent the whole population, a small part of a population randomly selected for analysis

scale -- a statement on a drawing or map that explains the relationship between the dimensions on the drawing and the true dimensions of the object. Scales can also be called *legends* or *keys*.

scatter diagrams -- charts which allow us to study correlations; the relationship between two variables

source -- information below a table or chart that tells where the data actually came from

SPC -- Statistical Process Control is a method companies use to achieve quality; a method of gathering and analyzing data to solve practical quality problems. Controlling the process with statistical methods to guide in the outcome of quality products or parts.

square root ($\sqrt{\ }$) -- the number which, when multiplied by itself, equals the number under the square root sign ($\sqrt{\ }$)

$\sqrt{4} = 2$ since $2 \times 2 = 4$

$\sqrt{9} = 3$ since $3 \times 3 = 9$

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statistics -- summaries of data; the science of collecting, organizing, and analyzing data to draw conclusions

stratification -- hardly any fluctuation on a control chart, the points are too close to the central line

- **sudden shift in level** -- a pattern indicated by an absolute change in one direction; that is when a number of X's appear on one side of the chart only

systematic variables -- a pattern which shows predictable tendencies
trends -- the continuous predictable movement of a pattern in either an upward or downward direction

table -- a graphic representation of data that lists exact numbers in columns and rows

technology -- Machines and ways of doing things that improve the speed and/or quality of work. The use of computers in manufacturing is an example of modern technology.

title -- the name that describes the chart or graph

- **trend** -- , a pattern of usually 4 or 5 successive points going up or going down, a direction of movement, in line graphs a tend shows upward or downward movement

U. S. customary units -- the way people in the United States usually measure, using units such as inches, feet, miles, ounces, and pounds. In many industries, U. S. customary units are being replaced by the metric system.

- **unnatural pattern** - any pattern in which significant numbers of the measurements do not group themselves around a center line; when the pattern is unnatural, it means that outside disturbances are present and are affecting the process

- **upper control limit** -- a horizontal line on a control chart (usually dotted) which represents the upper limits of our process capability

- **variables data**-- information that comes from measurements like the length of a shaft, the inside diameter of a drilled hole, the weight of a carton. Refers to data with measurement characteristics which can be assigned a numerical value, is quantifiable

vertical axis -- the line in a graph that runs up and down on the page |

width -- the distance from one side to another of something. In rectangles, the shorter dimension. The length of the rectangle was 50 centimeters, the width was 20 centimeters

- **x** -- an individual reading or observation

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- $\bar{x}$ (x bar) -- the $\bar{x}$ (x bar) average of a group of X's

- **$\bar{x}$ r charts** (x bar r charts) -- a control chart which is a representation of processes capability over time

zero defects -- the idea that prevention is the goal and no defects should be tolerated.

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Math Preview for SPC-Prep 1 (with fractions)

Name _____ Participant ID #_____

Project Course #_____ Date _____

Directions: Show your work by the problem or use the last 2 pages. Put your answer next to the problem and (circle) it.

1.
$$\begin{array}{r} 18 \\ 49 \\ 22 \\ 23 \\ +\ 16 \\ \hline \end{array}$$

2.
$$\begin{array}{r} 33.622 \\ 47.921 \\ 21.266 \\ 68.173 \\ +\ 59.365 \\ \hline \end{array}$$

3.
$$\begin{array}{r} 10{,}130 \\ -\ 1{,}769 \\ \hline \end{array}$$

4.
$$\begin{array}{r} 63.921 \\ -\ .812 \\ \hline \end{array}$$

5.
$$\begin{array}{r} 27 \\ \times\ 94 \\ \hline \end{array}$$

6.
$$\begin{array}{r} 4{,}983 \\ \times\ 569 \\ \hline \end{array}$$

7. $5\overline{)8{,}157}$

8. $5\overline{)128.0}$

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9. $\frac{1}{6} + \frac{1}{6} =$

10. $\frac{7}{8} - \frac{7}{9} =$

11. $3\frac{5}{8} + 1\frac{1}{4} =$

12. $2\frac{3}{4} - \frac{1}{4} =$

13. $\frac{2}{5} \times \frac{3}{7} =$

14. $3\frac{1}{2} \times \frac{2}{25} =$

15. $\frac{1}{2} \div \frac{1}{8} =$

16. $5.3 + .04 + 1.005 =$

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17. $1.4 + .002 + .08 =$

18. $1.6 - 0.2 =$

19. $11.03 - .009 =$

20. $4.5 \times 7.1 =$

21. $.45 \times .035 =$

22. $8.9 \div .013 =$

23. $5.41 \div .12 =$

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24-29. Fill in the missing equivalents in the table below.

Fraction	Decimal	Percent
$\frac{1}{8}$	.125	12.5%
24.	.60	
25.		$66\frac{2}{3}\%$
26. $\frac{1}{16}$		
27.	.03125	
28.		45%
29. $\frac{1}{12}$		

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30. $-25 + 17 =$

31. $-25 + (-17) =$

32.

$$\begin{array}{r} .023 \\ -.041 \\ .009 \\ -.101 \\ \underline{.276} \end{array}$$

33. What is the decimal number for six-tenths? _____

34. What is the decimal number for seven and three-hundredths?

_____

35. What is the decimal number for thirteen and sixty-seven thousandths? _____

36. What is the decimal number for $\frac{6}{100}$? _____

37. What is the decimal number for $7\ \frac{16}{10{,}000}$? _____

38. Round 0.982 to the nearest tenth. _____

39. Round 3.4369 to the nearest hundredth. _____

40. Round 0.0861 to the nearest thousandth. _____

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Math Preview for SPC-Prep 1 (without fractions)

Name _____ Participant ID #_____

Project Course #_____ Date _____

Directions: Show your work by the problem or use the last 2 pages. Put your answer next to the problem and (circle) it.

1.
18
49
22
23
+ 16

2.
33.622
47.921
21.266
68.173
+ 59.365

3.
10,130
- 1,769

4.
63.921
- .812

5.
27
x 94

6.
4,983
x 569

7. $5\overline{)8,157}$

8. $5\overline{)128.0}$

9 5.3 + .04 + 1.005 =

10. 1.4 + .002 + .08 =

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11. 1.6 - 0.2 =

12 11.03 - .009 =

13. . 4.5 X 7.1 =

14 .45 X .035 =

15. . 8.9 -:- .013 =

16. 5.41 -:- .12 =

17 -25 +17=

18.. -25 + (-17) =

19.

.023
-.041
.009
-.101
.276

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20. What is the decimal number for six-tenths? _____

21. What is the decimal number for seven and three-hundredths?

_____

22. What is the decimal number for thirteen and sixty-seven thousandths?

_____

23. Round 0.982 to the nearest tenth. _____

24. Round 3.4369 to the nearest hundredth. _____

25. Round 0.0861 to the nearest thousandth. _____

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Math Review for SPC-Prep 1 (with fractions)

Name _____ Participant ID #_____

Project Course #_____ Date _____

Directions: Show your work by the problem or use the last 2 pages. Put your answer next to the problem and (circle) it.

1.
$$\begin{array}{r} 18 \\ 49 \\ 22 \\ 23 \\ +\ 16 \\ \hline \end{array}$$

2.
$$\begin{array}{r} 33.622 \\ 47.921 \\ 21.266 \\ 68.173 \\ +\ 59.365 \\ \hline \end{array}$$

3.
$$\begin{array}{r} 10{,}130 \\ -\ 1{,}769 \\ \hline \end{array}$$

4.
$$\begin{array}{r} 63.921 \\ -\ .812 \\ \hline \end{array}$$

5.
$$\begin{array}{r} 27 \\ \times 94 \\ \hline \end{array}$$

6.
$$\begin{array}{r} 4{,}983 \\ \times 569 \\ \hline \end{array}$$

7. $5\overline{)8{,}157}$

8. $5\overline{)128.0}$

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Math Review for SPC-Prep 1 (without Fractions)

Name _____ Participant ID #_____

Project Course #_____ Date _____

Directions: Show your work by the problem or use the last 2 pages. Put your answer next to the problem and (circle) it.

1.
$$\begin{array}{r} 18 \\ 49 \\ 22 \\ 23 \\ +\ 16 \\ \hline \end{array}$$

2.
$$\begin{array}{r} 33.622 \\ 47.921 \\ 21.266 \\ 68.173 \\ +\ 59.365 \\ \hline \end{array}$$

3.
$$\begin{array}{r} 10{,}130 \\ -\ 1{,}769 \\ \hline \end{array}$$

4.
$$\begin{array}{r} 63.921 \\ -\ .812 \\ \hline \end{array}$$

5.
$$\begin{array}{r} 27 \\ \times\ 94 \\ \hline \end{array}$$

6.
$$\begin{array}{r} 4{,}983 \\ \times\ 569 \\ \hline \end{array}$$

7. $5\overline{)8{,}157}$

8. $5\overline{)128.0}$

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Scoring Guide for the SPC-Prep 1 Preview and Review

There are 45 correct answers on the SPC-1 Pre/Post test *with* Fractions All answers are equal in value. (Questions 24-29 have two responses each.) An employee must have 32 correct answers overall and problems 2, 8 17, 30, and 32 must be answered correctly to meet criteria set by union and management at the pilot site. You should ask trainers of SPC in the company you are working in to decide what skills are needed by those doing SPC so you can set criteria for successful completion at your site.

In cases where scores are marginal or mandatory problems are incorrect, the instructor will decide (by looking at the computations made on the test) whether the employee understands the concept and made a simple mathematical error or if employee does not know the underlying concept.

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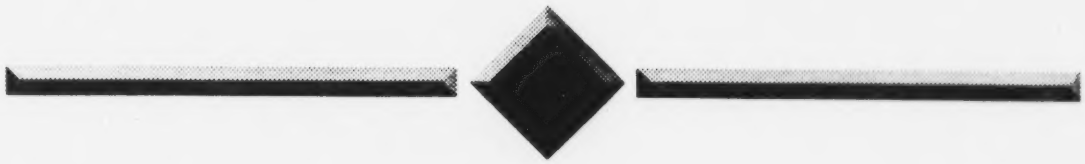

SPC-Prep 2 Concepts & Applications

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Keeping Track of Learning

I. Understanding /Outcome: How to use the SPC-Prep Daily Report

II. Materials: Accompanying supplementary materials: *SPC-Prep Daily Report*

III. Demonstration	
Activate prior knowledge. Have you ever had to keep track of something over a period of time? (Giving medications to a sick person, tracking the performance of a problem, etc.) What is the value of keeping a written record of a process?	Suggested activities.

IV. Exercise/Engagement:	
Ask students to look over the SPC-Prep Daily Report form . Discuss the way the form will be used in class each session.	

V. Workplace Application: Keeping written records of progress is valuable.

VI. Evaluation/Comments:

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SPC-Prep Daily Report

Name: _____ Date: _____ Time _____

Today's topic: _____

What I learned today: _____

Why do I need to know this? _____

How did I learn this? _____

What I need more practice with: _____

What would be helpful for me to learn: _____

I am ready to move on to the next topic. ❒ Yes ❒ No

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The Need for Quality

I. Understanding /Outcome: To become aware of the need for quality

Materials: Black board or flip chart to track discussion points Accompanying supplementary materials:

III. Demonstration	
Activate prior knowledge. 1. Ask students about their experience with buying products that did not meet their expectations? Elicit responses from students. 2. Ask what response they had due to the lack of quality. Elicit responses from students 3. Discuss the consequences of poor quality in their experience.	Suggested activities. 1. "Have you ever bought an item at a store, or even sent away for something, and when you got it home and examined it, it didn't measure up to your expectation? 2. What did you think and/or feel when the quality of a product doesn't meet your expectations? 3. "What could be the result of poor quality for the users of these items?" See *Glossary of Instructional Terms* for more explanation of methods suggested.

IV. Exercise/Engagement:	
1. In groups of 3 or 4, have students brainstorm ways that quality might be able to be maintained 2. Bring groups together and make a master list of suggestions generated.	1. Ask, " How might quality of products be assured or maintained so that every time you purchase an item, it would always meet your quality standards?" 2. Record all responses generated, even if they must be clarified or restated. If a response is duplicated, point out that it is already in the master list but put a check or star by it to indicate that it came up more than once.

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3. Lead students to consider the quality of the products made at their facility. Elicit responses. Do students have the same feelings about quality for products used in their personal lives as the products that are manufactured at the work site? 4. Lead students to consider ways of assuring and maintaining quality of products made at this site. List ways students think quality is maintained or controlled at work.. 5. Elicit responses to questions regarding quality improvement at the site. 6. For closure of this discussion, set up a scenario where management is paying cash for the best suggestions to improve quality. On the *SPC-Prep Daily Report*, under *What I learned today*, ask students to write their suggestions. If students have had problems with this session ask them to fill out the lower portion of the form. The next topic will be *Changes in the Approach to Quality through History*.	3. Ask, "How do you feel about the parts you produced here?" "If you were to have them on your car, would they meet your standard of quality? Would they perform in the way they were intended? How would you rate the quality of the items made here? 4. "In what ways is the quality of the products manufactured here being controlled or maintained? 5. Is there anything else that could be done that would improve the quality of the products made here?" 6. If you were to make recommendations to management for improving quality of products, what would you suggest?

V. Workplace Application: To provide foundation for the development of the concept of *quality*.

VI. Evaluation/Comments:

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Changes in the Approach to Quality through History

I. Understanding /Outcome: To understand the need for changes in the approach to quality because of changes in the society.

Materials: Black board, flip charts, SPC Daily Reports Accompanying supplementary materials: *A Short Version of the History of Quality*

III. Demonstration	
1. Activate prior knowledge. Ask students to consider how their life would have been different if they had lived in the past. Elicit responses.	Suggested activities. I want you to think about what your life would have been like if you lived in the 1700's and in one of the 13 colonies? What kind of life do you think you might have led? What do you think your job would have been? How would you have gotten what you needed--food, clothing, transportation, etc.? See *Glossary of Instructional Terms* for more explanation of methods suggested.

IV. Exercise/Engagement:	
1. What would the standard of quality be for your personal purchases? 2. What would you do if something did not meet your standards? 3. Where did that way of handling quality problems come from? 4. When did that change?	1. What would your standard of quality be for food, clothing, tools, etc.? 2. Lead this discussion to the craftsperson who made the products who must personally address their lack of quality. 3. Lead the discussion back to the European standards for craftsmanship. 4. Lead the discussion to the Industrial Revolution. At this point you can begin to plot major events on a time line. 5. What do you know about the Industrial

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5. Generate a discussion about the changes brought about by the Industrial Revolution.	Revolution? How important was Henry Ford? Use the article, *A short Version of the History of Quality* if it will fill in discussion gaps.

V. Workplace Application: Understanding the rationale for current quality practices gives a basis for teaching SPC related concepts.

VI. Evaluation/Comments:

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A Short Version of the History of Quality

The Early Years in Europe

The history of quality goes as far back as the Middle Ages (from about 480 AD to 1470 AD). Craftsmen and women in Europe understood the need for quality. All work was done by hand. The craftspersons knew what their customers wanted. They made their goods to please the customer. There was no need for a separate inspection process. If some flaw or problem was found, it was repaired by the craftsperson. Problems with quality were handled directly. (I make it. You don't like what I make. I fix it so you like it. I get paid.) Reputations were built on craftsmanship. There was much pride in workmanship. One person followed the entire process of making something from the beginning to the end. The same person may have even been part of the design process.

The Early Years in America

This work standard from Europe came to America with the early settlers. The work of many early American craftsmen is still valued today. Paul Revere was a silversmith long before he took his famous ride in 1776. His silver bowls and pitchers are highly prized by museums and private collectors. This high standard of quality continued until the Industrial Revolution in the late 1700s.

After the Industrial Revolution

With the Industrial Revolution came the mass production of goods. This meant that interchangeable parts were important. One person did NOT follow a product from start to finish. One person played a small part in this large process. Henry Ford was one of the pioneers of the assembly line. As he produced the Model T, it was important to have parts that fit correctly as they were added on the assembly line. The whole process of manufacturing changed a great deal. Engineers drew up blueprints of all the separate parts of machines. Tool makers designed tools that would make parts that conformed (were alike in form) to the blue prints. Inspection became a separate and important step of the production process.

The 1920s, 30s, and 40s

During the 1920s and 30s, engineers also began using statistical techniques in the inspection step of the production

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process. Sample parts were inspected to see if they conformed to the customer needs. These statistical techniques were part of a quality improvement plan. They were used with success at Western Electric and Bell Telephone. These techniques were also taught to engineers and used during World War II.

The 1950s and 60s

The 1950s were prosperous years for America. Quality improvement was not very important to manufacturers. The United States was the world leader in manufacturing. It was during this time that statistical quality improvement techniques were ignored by manufacturers. The United States had a captive market. There was no foreign competition. The countries who would become our greatest competitors were rebuilding after World War II.

During the 1950s and 60s, American manufacturers used quality control methods that depended mostly on inspection of the *finished* product. The product either worked or it didn't. The parts were either good or bad. Production runs were scheduled for *more* than the number of parts ordered to allow for scrap and reworked parts. If you needed 1000 pieces, you might have to make 1,250 or 1,400 to allow for those parts that would not pass inspection. Times were good. Everyone was making money. There was no competition. There was no pressing need to improve the quality of production.

It was also during the 1950's that two Americans, W. Edwards Deming and Joseph Juran, were invited to Japan. The Japanese wanted help with their rebuilding efforts. These two men taught the Japanese the importance of quality and the use of statistical methods to improve quality. By using Deming's teachings, the Japanese improved the quality of their products and services. Japanese goods had once been considered junk. They used the methods the Americans taught them. Soon they began to be respected as the standard for quality and value.

Unfortunately, American businesses did not begin to adopt quality standards until they had no choice. They began to lose their markets to foreign competition.

The 1970s, 80s, and 90s

The 70s, 80s and 90s brought many changes. These were the years of major layoffs, recession, and reorganization of many companies.

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Today

One lesson is now clear. We have learned from Japan and other Asian countries that we must pay attention to quality. Quality is now the responsibility of everyone in the organization. Quality Control departments became Quality Assurance departments. It was clear that companies had to *assure* their customers that quality would be delivered with their products. Competition forced American business to look at the entire production process and find ways to improve it. If the number of scrapped pieces could be lowered, profits would go up. If there were fewer parts to rework, production rates would increase. If mistakes could be found and corrected as they were being made, everyone would benefit. Soon every business was trying to work smarter. Continuous improvement was the new way of thinking. Continuous improvement was one of Deming's ideas. He believed at every stage of work there must be a continual improvement of methods and procedures.

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Quality in the Workplace

I. Understanding /Outcome: To understand the concept of *quality* in the workplace as related to design and conformance..

II. Materials: Accompanying supplementary materials: *What is **quality** in the workplace?*

III. Demonstration	
Activate prior knowledge. Have you or someone you know, ever gone to the doctor and received a list of medications and or treatments to follow? (Hopefully, yes) Do you tell the doctor what medications or treatments to give you? (Usually not- you many have some experience but usually you don't know the full scope of medications/treatments available.) Did you follow the doctor's orders exactly? (Take temperature 3 times per day, wake up and check the eyes of someone who may have a concussion, medication one time, etc.) Did the medication/treatment work? (Sometimes yes, sometimes, no.) Discuss the quality of the design that the doctor prescribed and the quality of conformance of sticking to the plan.	Suggested activities. If no- Make one up for the sake of discussion

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IV. Exercise/Engagement:	
1. Set up a budget that a 10 year old might set up for a family of 4 on $500 per week. 2. Come together and share the budgets. 3. If the budget was followed exactly, could all the needs of the family be met? 4. Discuss the difference between quality of design and quality of conformance. 5. Read Quality in the work place. 6. Discuss the employees' role in quality in the workplace. Do employees have control of design and or conformance?	1. In groups or pairs

V. Workplace Application: A basic understanding of quality for QS9000

VI. Evaluation/Comments:

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What is Quality in the Workplace?

Quality can be defined many ways. The dictionary gives these two definitions of *quality:*

1. A characteristic, attribute, or property -- He has many good qualities.

2. The degree or grade of excellence -- The service at the restaurant was of poor quality.

Quality relates to the production of parts in a very specific way. Quality must be designed into a product. Once the product is designed to meet the needs of the customers, the manufacturer must make sure that design standards and specifications are met. This is called *conformance to specifications*. Quality involves 2 major parts:

1.) Quality of design

2.) Quality of conformance.

One definition of quality in manufacturing is **the total of the features and characteristics of a product that bears on its ability to satisfy given needs.** *To satisfy given needs* means to be able to identify the features and characteristics of the product that customer wants.

In most manufacturing companies, the production workers have little or no voice in the *quality of design*. However, workers are now given the responsibility for tracking the *quality of conformance*. The questions workers must answer is, "Are you making good parts?" "Do they meet the specifications?" "Will they pass inspection?"

Quality is *defined* by specifications and it is *achieved* by production. The workers on the line are concerned with the *quality of conformance*. Many things can happen during manufacturing operations. Machine settings can fall out of adjustment; operators and assemblers can make mistakes; materials can be defective. Even under the most closely controlled conditions, there will always be variations or differences in production output.

The responsibility of production is to make sure that product specifications are met and that the final product performs as intended.

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Introduction to Statistics

I. Understanding /Outcome: Understanding the basic concept of statistics.

II. Materials: Accompanying supplementary materials: *What are Statistics?*

III. Demonstration	
Activate prior knowledge. 1. When I say the word *statistics*, what do you think of? 2. Who uses statistics? 3. Do you keep track of anything with numbers? (Gas mileage, utility bills, sports, stock market, etc.)	Suggested activities.

IV. Exercise/Engagement:	
1. Read *What are statistics?* 2. Collect data on a topic that can be completed during class in groups. 3. Organize the data so you can give a report to the class. 4. Can you make any predictions or interpretations based on the data collected?	1 Read in pairs or individually. 2. Gather data on a topic like: Have you worked for more than one company in the last 5 years? Have you changed the make of car that you drive in the last 5 years? Has the sport you like to watch most on TV changed in the last 6 months? 3. Do you think the data is representative of the whole company? 4. If the data collected is not about a change, it may be difficult to make predictions or interpretations.

V. Workplace Application: A basic understanding of statistics gives a context for

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understanding SPC.

VI. Evaluation/Comments:

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What are Statistics?

We see and hear about statistics every day on the job, in the news, and on TV. Here are some examples of statistics:

- There's a 40% chance of rain
- The unemployment rate is 7%.
- 3 out of 4 people prefer Brand X
- $3 million will be cut from the district education budget
- Earned Run Averages (ERA) in baseball
- Percent of Pass Completions in football
- The average daily high and low temperatures
- The consumer price index
- The number of car accidents over a holiday weekend

Some people become uncomfortable when faced with statistics. This may be because the language of mathematics uses symbols, expressions, and graphs that are unfamiliar. Take some time to notice the numbers you see around you in articles, advertisements, reports and numbers you hear on the radio or TV. Think about how these numbers are interpreted. You might interpret them differently. Although numbers may be based on facts, the statements made about them are not always accurate.

Data is defined as information that is organized for analysis or decision making. Data refers to the collection of numbers that give us information about a subject. Data is used to analyze situations and make decisions. Many types of data are collected. If you have ever filled out a census form or responded to a telephone survey, you have supplied data that some person or organization is collecting.

Which of the following forms of data collection have you done?

- ❒ Questionnaire
- ❒ Consumer product survey
- ❒ Credit or job application form
- ❒ US Census form
- ❒ Opinion poll
- ❒ Voting
- ❒ Other What was it?

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Introduction to Statistics

Statistics refers to the collection, organization, and interpretation of information, also known as *data*.

In the *collection* stage, the numbers are gathered.

In *organization*, numbers are counted and put in some order that is reasonable or easy to understand.

In *interpretation*, the numbers are explained or given a meaning.

Sometimes percents are used to give statistics. Percent means "out of one hundred." If an article said 71 people out of 100 said that the government should provide child care, then 71% of the people think the government should provide child care. If 4,500 people were asked about government provided child care and 3,195 said that they think it should be provided--that is also 71%.

Sometimes fractions are used to interpret the data. It could be said that about 7/10 of the respondents (people who responded to the survey) were in favor of government provided child care.

Ratios are another way to present data-- 7 out of 10 (7:10) respondents favored government provided child care. Ratios are most often written in fraction form.

A number is not large or small until it is compared to another number. When you hear a number, be careful not to make a judgment about its size until you have a chance to compare it to related numbers.

For example, did you know that on an average day in 1989 the government spent $46 million on education? That may seem like a very large amount. Did you know that on an average day in 1989, the government spent $807 million on defense?

In manufacturing, information is gathered about the production process. Think about the number of parts rejected on a shift. If 4 parts were rejected during one shift, you might think that was a good day. If the machine was down for most of the shift, and only a total of 5 parts were made, then 80% (4 is 80% of 5) of the parts were rejected. *The relationship of the numbers is more important than the numbers themselves.*

There are special terms used in statistics. A **population** is all of the possible items of interest in a particular study. The focus of the study might be all the Jaguar flywheels. So the population being looked at is the Jaguar flywheels. Usually the population of interest is

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so large that it is not possible to collect all the data on the entire population. Instead, a **sample** is selected. A **sample** is the part of the population that is chosen to represent the whole population. A population might be 15,000 parts that are required by a supplier. Only 30 parts might be selected to check for acceptable quality. These 30 pieces are the *sample*.

Another example of a *population* could be all parts that can be produced by a machine at a certain point in time, like 10:00 AM. If the first 5 parts that are produced at 10 AM are selected, it is a *sample*.

A single data value in a sample is an **observance.** The purpose of collecting sample data is to draw conclusions about the population. This is what the science of statistics is about. It is the foundation for Statistical Process Control--SPC.

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Statistical Terms

Like every subject, statistics has its own set of words and symbols. Once you are familiar with them, statistics will be easier to understand.

Sample size is often referred to as ***n***. If you are looking a 100 different parts during the shift, your sample size or ***n*** is 100.

An ***observation*** is a single data value in a sample. For example, fly wheels are checked several times during each shift. Each time data is collected on a flywheel is one ***observation.***

On many charts, several numbers are added together. The sum is divided by the number of observations to find the ***average***. The average is often referred to as ***x***. Fox example, three samples are recorded on the control chart as 40, 48, and 36. These numbers represent three observations. They are added together and then divided by 3. This gives the **average** or **x** of 41.3.

```
   40          41.3
   48       3 / 124
+  36          12
  124           4
                3
                1
```

The ***range*** is represent by ***R***. The difference between the largest and smallest numbers in he sample is the range. In our example, the largest number is 48 and the smallest number is 36. To find the R or range, subtract the smallest number, 36, from the largest number, 48.

```
   48
 - 36        R = 12

   12
```

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Practice Exercises

Find the total for each time. Find the average or x. Find the range or R.

Time	8:00	10:00	12:00	2:00	4:00
Sample 1	19	15	17	9	15
Sample 2	11	7	9	13	13
Sample 3	14	16	18	16	9
Total					
X					
R					

What is the n at 8:00? _____

How many observations are shown on this chart? _____

Find the total for each time. Find the average or x. Find the range or R.

Time	8:00	10:00	12:00	2:00	4:00
Sample 1	23	18	15	35	29
Sample 2	12	9	16	24	17
Sample 3	10	6	9	18	11
Sample 4	8	13	11	17	23
Sample 5	15	11	13	28	15
Total					
X					
R					

What is the n at 8:00? _____

How many observations are shown on this chart? _____

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What is Statistical Process Control?

In any process, problems can occur. In the process of getting to work, there are many things that can make you late or absent. You could get sick. You may have an emergency with someone in your family. Your alarm clock may not wake you. Your car may not start. Your regular route to work could be closed due to construction. All of these are examples of ***variables*** that could affect your arrival at work.

Variables in the manufacturing process fall into some general categories: people, materials, machines, and methods. In order for quality products to be produced the people who work on the lines must understand how to do their jobs. They must also be there to do the work. Materials must be where they are needed in the right amounts. Materials must also be of good quality. Machines of all sorts must be in good running condition and be adjusted to the proper settings to make parts that meet the customer's needs. The methods by which the work is done must be efficient and effective so production quotas can be met on time.

In order to know what is happening during production, we collect and analyze data from the production process. Data is factual information, such as measurements or production numbers. *Statistics* is the science of collecting, organizing, and analyzing information (data) to draw conclusions.

One of the tools used to monitor and improve quality is Statistical Process Control--SPC. Its methods and techniques play an important role in making sure the manufacturing process produces quality parts.

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Recognize, use and understand SPC terminology

I. Understanding /Outcome: Recognize, use, and understand vocabulary related to SPC.

II. Materials: Company specific SPC charts and materials Accompanying supplementary materials:

III. Demonstration	
Activate prior knowledge. 1. Do you remember going to buy a house or car for the first time, and hearing words that you did not know and understand? 2. Choose a topic like *taxes, computers, hospitals, sports, funerals, unions, motorcycles* etc. and brainstorm all of the terms related to it. 3. Chart the responses on the board and point out words that have more than one meaning.	Suggested activities. 1. Develop the concept of specific vocabulary for a subject. 2. Use this activity for modeling exercise that students will do in small groups. 3. Words have different meanings in different situations. This will be an opportunity to demonstrate that learning never stops. Being uninvolved to SPC activities, you will not have as much experience with SPC vocabulary as your students. Give them an opportunity to teach you their "language."

IV. Exercise/Engagement:	
1. In small groups, have students brainstorm a list of words that relate to a topic. 2. Have groups share their lists. 3. Have students write a list of all the	1 Students have a chance to think about words related to topics of their choice. 2. Reinforce that all topics come with a special vocabulary and that words have different meanings based on their use. 3. Ask everyone to write a list on the back of

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words they know related to SPC. (Ask them to recall the words that gave them trouble when they started working here. They may be related to SPC.) Those who have difficulty may work with a partner. 4. Refer to glossary in the back of the participant guide and have students look to see if their words are included. Are there words that are not in the glossary that should be? Add the words that are not in the glossary.	the SPC-Daily Report so it is dated. At the end of the course, repeat this activity and compare the depth of knowledge.

V. Workplace Application: To recognize, use, and understand SPC-related vocabulary to be better able to read and comprehend workplace materials and SPC.

VI. Evaluation/Comments:

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Introduction to tables, charts, and graphs.

I. Understanding /Outcome: Tables, charts, and graphs represent information.

II. Materials: Accompanying supplementary materials: *Tables, charts, and graphs Types of graphs*

III. Demonstration	
Activate prior knowledge. 1. When I say *table, chart, or graph*, what comes to your mind? 2. When do you see tables, graphs, and charts? At home? at work? 3. Why are tables, charts and graphs used? 4. Are they useful or helpful?	Suggested activities.

IV. Exercise/Engagement:	
1. Collect data on a topic - 5 minutes 2. Represent data using a table, chart or graph. 3. Present table, chart or graph to group. 4. Introduce the parts of tables, charts, graphs. 5. Have students modify their tables charts, graphs to include a title, source, and heading.	1. Make of car, where you buy groceries, favorite fast food restaurant, favorite pizza, favorite ice cream, or select your own.

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V. Workplace Application: To develop understanding of tables, charts, and graphs, as representing information relating to SPC.

VI. Evaluation/Comments:

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Tables, Charts, and Graphs

What are tables and charts?

For our purpose, tables and charts are a way to list exact numbers in columns and rows..

What are graphs?

Graphs are a way of picturing the data. There are many types of graphs. The most common use bars, lines or a circle cut into parts.

Why are tables and charts often used to display data?

Tables and charts are pictures of the data and list exact numbers in columns and rows. Tables and charts make quick comparisons of numbers easy. Tables and charts allow for more accuracy than graphs because tables and charts provide the actual numbers.

How are tables and charts made?

Tables and charts are usually arranged in **columns** and **rows**. **Columns** are groups of numbers or words that are listed up and down or vertically. Rows are groups of numbers or words that are listed across from right to left or horizontally. To find specific information in a table or chart, read across a row and up or down the column to where the row and column meet or **intersect**.

What are the important parts of tables and charts?

When reading tables and charts there are 4 important parts:

- the **title** -- describes the subject of the table or chart
- the **headings** -- column and row labels that show what information is provided
- the **data** -- the numbers listed under and next to the headings, that give the specific information
- the **source** -- tells where the data came from and is usually located below a table or chart

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Types of Graphs

Graphs let us show data (information in numbers) in a picture form. There are many types of graphs. Some are:

Circle graphs or pie charts

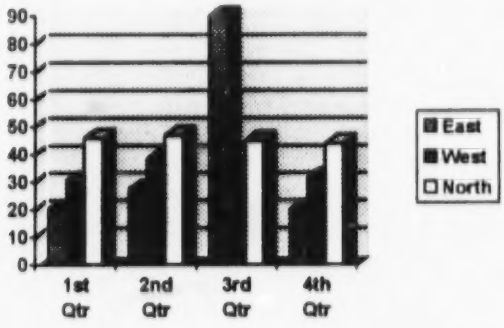
Bar graphs

Line graphs

A table shows the data (information) that has been collected.

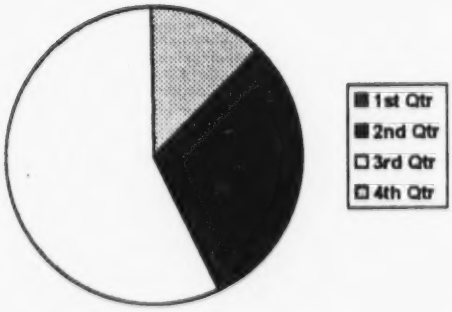
	1st qtr.	2nd qtr.	3rd qtr.	4th qtr.
East	20.4	27.4	90	20.4
West	30.6	38.6	34.6	31.6
North	45.9	46.9	45.	43.9

Each of the following graphs shows the data a different way



Bar graph

A Pareto chart is a kind of bar graph.



Circle graph or pie chart

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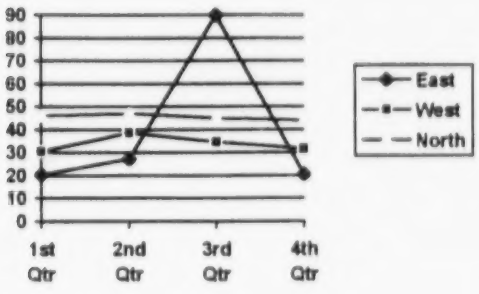
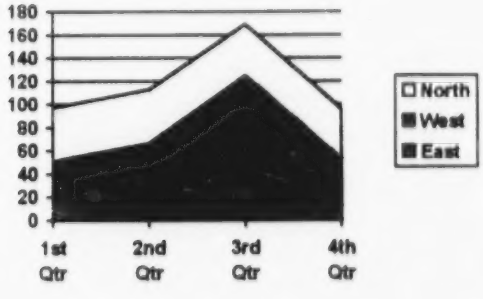
Circle graphs or pie charts represent a whole. If the total production of a manufacturing company is made up of fly wheels and oil pans, once the percentage of the production is figured out, it can be represented by a pie chart.



Line graph

Line graphs usually used to display a trend.



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Acceptable Range

I. Understanding /Outcome:
Understanding the concept of acceptable range-- normal, average, median, finding averages.

Materials:
Blackboard and chalk, (flip charts and markers) paper, pencil

III. Demonstration	
Activate prior knowledge. Introduce concept of "acceptable range."	Suggested activities. "Have you ever had a cup of coffee that was too hot or too cold?" What would you consider to be an acceptable range? What is just right? Not too hot so as to burn your tongue or so cold that you wouldn't want to drink it. Can you think of other examples of acceptable range? (Temperature of bath water, air in tires, the way clothing fits, lunch meat being weighed- too much too little, temperature in room.)

IV. Exercise/Engagement:	
Determine range, average and median using every day examples.	To find out what is normal or acceptable, we need to determine the "average" of the items under consideration.

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Find average by totaling the numbers and dividing total by the number of subjects. Find the median by finding the middle numeral. Find range by subtracting lowest number from highest number. Develop a work place scenario for number of parts produced to illustrate concepts. Handout on related topics for discussion or reinforcing concepts. information	List ages of the group, distances they drive to work, number of children, number of TV's or cars, daily temperature of the past week. Add numbers, divide by the number in set. To find median, list numbers from high to low and locate the middle number. To find range, subtract the lowest number from the highest number

V. Workplace Application: Acceptable range is a concept necessary for SPC calculations.

VI. Evaluation/Comments

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QS9000 --What can customers expect from a supplier's quality system?

With QS 9000, a customer can expect a supplier has certain procedures that will assure quality.

- The supplier must prepare a quality manual that addresses all of the requirements of the QS 9000 standard
- The supplier must have a stated quality policy.
- The manual must include documented procedures and work instructions to support the specified requirements within the quality manual.
- The manual must outline the structure of the documentation used in the quality system.
- The supplier must define and document how the requirements for quality will be met. This should include:
    - ◊ The preparation of quality plans and documented procedures that concur (agree) with the requirements of QS 9000 and the supplier's stated quality policy.
    - ◊ The identification and acquisition of any controls, processes, equipment, fixtures, resources and skills that may be needed to achieve the required quality.
    - ◊ Documented means for identifying customer requirements and translating those customer requirements effectively into design, production and delivery of product and services.
    - ◊ The updating of quality control inspection and testing techniques, and the development of new instrumentation, as necessary.
    - ◊ Measurement, testing and control equipment for assessing quality which utilize recognized procedures and meet documented external standards.
    - ◊ A system for evaluating the process capability that allows sufficient lead time for anticipated capability requirements to be met.
    - ◊ Standard of acceptability must be clarified for product features and requirements.
    - ◊ The preparation of quality records.

The supplier's quality system must be accessible to and easily understood by all personnel whose duties and activities have any bearing upon quality. It should take into account all facility functions and should provide for the keeping of pertinent records. (Taken from Perry Johnson, Inc. materials.)

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Preview for SPC Prep 2

Name _____ Participant ID #_____
Project Course #_____ Date _____

1. SPC stands for **S**_____ **P**_____ **C**_____

2. Where did Deming introduce his concepts of SPC to manufacturing?

   a. Germany b. Japan

   c. United States d. Sweden

3. Who has the responsibility for quality in your company? _____

4. The 2 kinds of quality that are important to a manufacturer are:

Quality of _____ Quality of _____

5. Which type of quaility from question 4. is most important for production workers? _____

6. Define *data.*_____

_____

7. In order to make adjustments to a process, what does a machine operator collect? _____

8. The four categories are used to analyze problems in manufacturing?

_____ _____

_____ _____

9. What is the purpose of putting manufacturing data into tables charts and graphs?_____

_____

10. What type of graph is a Pareto chart?

a. scatter plot b. Line graph c. bar chart d. pie chart

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Review for SPC Prep 2

Name _____ Participant ID #_____
Project Course #_____ Date _____

1. SPC stands for **S**_____ **P**_____ **C**_____

2. Where did Deming introduce his concepts of SPC to manufacturing?

   a. Germany b. Japan

   c. United States d. Sweden

3. Who has the responsibility for quality in your company? _____

4. The 2 kinds of quality that are important to a manufacturer are:

Quality of _____ Quality of _____

5. Which type of quaility from question 4. is most important for production workers? _____

6. Define *data.*_____

_____

7. In order to make adjustments to a process, what does a machine operator collect? _____

8. What are the four categories used to analyze problems in manufacturing?

_____ _____

_____ _____

9. What is the purpose of putting manufacturing data into tables charts and graphs?_____

_____

10. What type of graph is a Pareto chart?

a. scatter plot b. Line graph c. bar chart d. pie chart

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Answer Key for ***Preview and Review for SPC-Prep 2***

1. SPC stands for ***Statistical Process Control***

2. Where did Deming introduce his concepts of SPC to manufacturing?

   a. Germany b. Japan

   c. United States d. Sweden

3. Who has the responsibility for quality in your company? ***everyone***.

4. The 2 kinds of quality that are important to a manufacturer are:

   quality of ***design***

   quality of ***conformance***

5. Which type of quaility from question 4. is most important for production workers? Quality of ***conformance***

6. Define *data*. ***Information that is organized for analysis or decision making***.

7. In order to make adjustments to a process, what does a machine operator collect? ***sample data***

8. What are the four categories used to analyze problems in manufacturing?

   People ***Machines***

   Materials ***Methods***

9. What is the purpose of putting manufacturing data into tables charts and graphs? ***Tables and charts make quick comparisons of numbers easy . Tables and charts display actual data.***

10. . What type of graph is a Pareto chart?

a. scatter plot b. Line graph ***c. bar chart*** d. pie chart

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